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Variable Stars

It is possible that to some persons the combination of the words of the title denotes a contradiction. For there are some to whom the stars are the ultimate expression of that which is fixed, eternal, and unchanging. Those persons, no doubt, feel at least a slight antagonism to ideas which imply that such is not the case. It is true that one may scan the starry sky diligently from youth to old age without noticing any change. But the life of any man is negligibly short in comparison with the life of the stars, and careful scrutiny with suitable instruments proves without doubt that the configurations of the stars change perceptibly in the course of centuries and millenia.

But the words of the title, as ordinarily understood, imply not variableness of relative position but variableness in the amount of light emitted. This change in light intensity is in no case strikingly apparent, and in only a few instances is it detectable without instrumental aid. But there are more than ten thousand stars now listed in which such change unmistakably takes place. Like most of nature's processes, these changes are usually rhythmical and orderly.

Discovery of the facts just stated is the result of persevering and painstaking efforts on the part of many interested persons scattered throughout the civilized world. The largest group engaged in this phase of work is known as the American Association of Variable Star Observers. The number of individual observations made by this group and placed on record has mounted to considerably more than one million. Recently the Russian astronomers, professional and amateur, have made notable contributions to this great accumulation of data. Unfortunately, however, for most persons outside the U.S.S.R., their results are published exclusively in the Russian language.

At first thought it might seem trivial to record that today a certain star is a tenth of a magnitude brighter or fainter than it was yesterday. But further reflection leads to the thrilling thought that a century hence, perhaps, such a simple record in combination with others like it may aid in the discovery of facts and laws at present completely hidden. Thus one's work lives after him and thus one achieves a measure of immortality. —C.H.G.

V-2 Rockets in Exploration and Science

By DORRIT HOFFLEIT

As rockets reach higher and higher altitudes, man's imagination and desire also reach ever farther and farther out into space. We are, most of us, travel minded; and exploration of unknown worlds presents far more fascination than travel with a Baedeker. Before the war was over Willy Ley wrote* "V-2 proves that it is possible to build liquid fuel rockets of almost any size. . . With such pumps you can, given a little time, even build a space ship. . . As a matter of fact, this is no longer in the future; the first space ship has been built already, only it is not used as such. Yes, we might as well admit it, V-2 is the first space ship. . . Take off the bomb. . . This gives you another nineteen hundred pounds of fuel. . . It will ascend beyond two hundred miles—it will just touch empty space!" No sooner were the V-2 rockets, launched at White Sands, reported to ascend to altitudes of a hundred miles, with promises that future new missiles would soon be reaching much greater distances, than the public began to extrapolate. Thus a letter was received at Harvard from a good looking (her picture enclosed), though, we fear, frustrated young Italian lady indicating something of dissatisfaction with her post-war life, and offering herself quite altruistically to immortal fame. Without strings attached, she was volunteering to be the first human passenger to venture a space ship ride to the moon. She seemed to imply that in the *experiment* of space travel there might be some uncertainties of survival. Otherwise she would rather have inquired about the price of a ticket! Indeed the V-2 expert, Dr. J. A. van Allen of Johns Hopkins University, in an account in the *Explorer's Journal*, stated it would be "most immoral" to accept any volunteer's offer to ride a V-2 today; it would simply be too hazardous.

Happening across a letter by an engineer to the editor of the *Journal of the British Interplanetary Society* a year ago, in which the writer comments on previous papers and discussions on space travel, I find that some men of the world have greater concern over the moral and political aspects than the physical dangers of venturing outside our own globe. This is illustrated by a few excerpts from the letter.

"We do not know what form life may take in other worlds, but we do know that the tragedy of the development of the New World was not the strife between European Nations, but the exploitation, degradation, and in some cases annihilation of the aborigines. . . The objective of many speakers seemed to be not the increase of human knowledge, but the desire that man should ultimately dominate more and more of the universe. . . Sooner or later we shall find inhabited worlds. We cannot say how soon that will be. So it is essential that, before the

*V-2: Rocket Cargo Ship, *cf.* "Adventures in Time and Space," Random House, 1946.

crisis is upon us, we should be prepared with a policy which will avoid the mistakes we made and the misery we caused in America and Australasia."

While I subscribe heartily to this policy wherever it is applicable, I fear that in the exploration of extraterrestrial space the pioneer is infinitely less apt to destroy other innocents than to be himself destroyed, inanimate nature being his only serious but nevertheless overpowering contestant. This well-known point is emphasized because views such as those quoted above are from time to time seriously incited by articles by students of rocketry—like a recent one in *Army Ordnance** in which an army reserve major presents an invasion of Mars as a "sober and not necessarily distant possibility" for securing a military outpost for World War III. While the major has the engineering difficulties well in mind, his faith in human endurance must be colossal even for an army officer. His theme is extended in the September, 1947, *Journal of the American Rocket Society,* from which we quote as follows:

"A plan which may soon prove practical is to send a colony to Mars which could establish industry there, build rockets, keep in touch with earth, and be in effect a pistol at the back of any aggressor who attempted to conquer the earth" (specifically America!). Alas, Admiral Byrd's experiences in Little America ("Alone") are as nothing compared to the prospects of a human invader of Mars.

Rocket development in the past decade has been so great, however, that it does not seem rash to predict that a rocket will reach the moon within another decade. In fact a recent *United Press* clipping (April 15) stated, "Rocket men believe they know enough right now to shoot a missile as far as the moon," but strangely, it adds, "Nobody can think of any good reason for wanting to do it." Of course, the article continues, everybody is *interested;* but is the interest commensurate with the cost, trouble, and risk? The trip, when we do make it, will not provide a fresh air sporting or sightseeing tour, as illustrated in the 1846 and 1860 previews of rocket travel (Figure 1, cartoons taken from Willy Ley's "Rockets"), or a *de luxe* pressurized cabin flight,

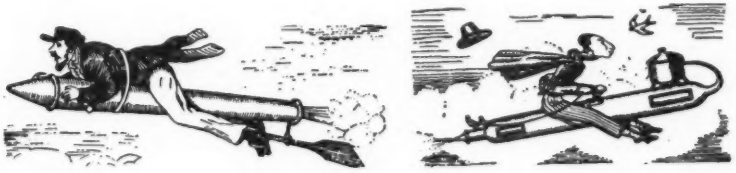

FIGURE 1

"Aerial Steam Horse" (about 1860) Caricature of Golightly's Projected "Aerial Steam Horse"

*March-April, 1947.

although Professor Henry Erikson at Minnesota has already described such a one. Weighing only about 135 tons, it might become available when atomic energy can be utilized for the necessary power to give his jet-propulsioned ship an exhaust speed of three miles a second. This, he admits,* is "at present extremely improbable." What we may, however, boldly hope for is to get a missile, without passenger, to escape from the gravitational hold of the earth so that it may wander off into space. Then if our early guiding has been very accurate we may succeed in making the rocket hit the moon. And if in addition we have provided it with an atomic-bomb war-head, we may actually set off an explosion on the moon just bright enough to be observed from the earth, provided we have been watchfully waiting for the flash. From what we know about the moon we are not worried about the chance of committing mass-murder, or even of killing an ant. Life in no form that we know could exist on the practically atmosphereless, barren moon. The experiment would be wholly of academic interest. If indeed we were superlatively fortunate, Dr. H. H. Nininger's hopes† might be realized, namely, that the force of the atomic explosion would be great enough to expel some chunks from the lunar surface, a few of which might land like meteorites on earth. They should not be consumed like most meteors in our atmosphere. Their velocities, 7 miles a second, would not be great enough to cause these small chunks to vaporize on impact with our atmosphere. Thus for the first time we might be able to handle a piece of the moon and subject it to standard chemical analysis. And even if the small chunks should vaporize at high altitudes, an alert astronomer might still learn from them a little more about the surface chemistry of the moon. With a battery of meteor spectrographs awaiting the event, he might be fortunate enough to get a spectrum of the vanishing, vaporizing lunar meteoroid, which would identify at least a few of the constituent elements of the moon. On the other hand, with poor planning and navigation of the original rocket, we have been warned, the rocket might miss the moon but subsequently return its explosive war-head to the earth. But don't worry! While the possibilities of hitting are extremely small at best, oceans and deserts occupy far more area than that which is inhabited.

While we are assuming that we actually can get away from the

TABLE 1

Exhaust Velocity Available (Meters per second)	——Initial Mass of Ship[1] (in tons)—— Earth-Mars-Earth with circling of planet	Earth-Venus-Earth, with circling of planet	Special Round Trip
3,000	65,500	40,000	46,300
4,000	9,400	6,330	6,700
5,000	3,100	2,160	2,160
10,000	356	284	244

[1] Ship without fuel = 6 tons.

**American Journal of Physics,* December, 1946; *Science Service,* 12/24/46.
†POPULAR ASTRONOMY, December, 1945.

earth, how about this trip to Mars? Here is a table Willy Ley prepared in 1943, and a diagram (Figure 2) which may help us plan most

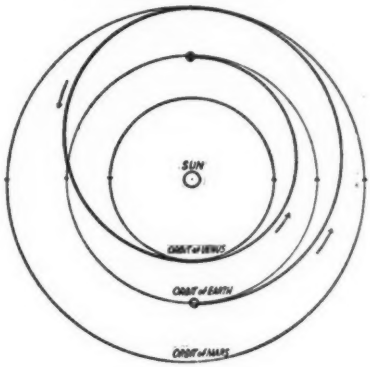

FIGURE 2
The so-called Hohmann Round Trip

economically. As in many mundane matters, the shortest route is not always the most practical. So we shall not plan the bee-line from the Earth to Mars, practically at right angles to the Earth's orbit. But remembering that the Earth imparts to the rocket its own component of motion, we need give the rocket only a differential motion in order to enable it to "coast" most of the way with comparatively little fuel expense. The tables and figures show that our best plan is to visit both Venus and Mars on the same round trip, since this is less expensive than the trip to Mars alone and only slightly more expensive than that to Venus. Be prepared for both super-torrid and sub-arctic conditions, though. Mars may be 100° F cooler than the Earth, and Venus 100° F warmer. Alas, however, one of our biggest problems is still our atmosphere. First it drags our space ship back; then when we have succeeded in overcoming this drag, we find we should have taken some of that air along because we just cannot live without it. And we won't find any to suit us on Mars, either. Its atmosphere is practically devoid of both oxygen and water vapor.

Moreover, assuming that we do find a way to survive the tremendous rocket accelerations necessary to get us beyond the Earth's atmosphere, and the serious respiratory effects of no air, or Martian air, there are yet other dangers. One that is frequently discussed is that of being hit by meteoroids which travel at speeds upwards of 30,000 miles an hour —velocities so great that an impact might instantaneously destroy our ship. Fortunately most meteoroids are small, and even in comparatively dense swarms they average only about one gram in 20 cubic miles of space. But just in case of one such accidental encounter, Dr. F. L. Whipple of Harvard comes to your assistance with a "meteorite bump-

er" to protect the ship or greatly reduce the probability of disaster. His bumper, a millimeter-thick shield separated by about an inch from the one-fourth inch-thick steel skin of the ship itself, would render harmless any collisions with bodies corresponding to 8th magnitude meteors. Such pebbles would weigh about a milligram each, and a collision with one of them should occur on the average of about once in 50 years of travel. Larger bodies would be more destructive, but the probabilities of encounters would be very much smaller.

Since there are as yet only a few practical and many impractical aspects to the problem of space travel, let us leave all this realm of hope and speculation for the time being and look soberly at some of the actual achievements of scientific exploration with rockets.

About 30 V-2 rockets have now been fired at the Army Ordnance Department's White Sands Proving Ground, New Mexico, most of which have reached altitudes greater than 50 miles. Each has carried scientific equipment for some special purpose like measuring the intensity of cosmic rays or upper atmosphere temperatures. These 50 to 115 mile exploratory trips into our atmosphere have been more costly per mile of travel than any *de luxe* tour you have ever taken. At approximately $75,000 per chartered trip, with no refunds in case of "bad weather" turn backs after a poor initial start, the average round trip fare might conservatively be estimated at $2,000 per mile. The first ten miles are especially expensive since this close-to-home territory can be more economically and thoroughly explored by other means (sounding balloons and even airplanes). Evidently, then, the explorations *via* the V-2 are not something that a single university or research group could readily finance for its own particular purposes alone. But through the cooperation of the Army, Navy, several engineering concerns, and universities, very expensive explorations have already paid significant dividends (non-monetary, to be sure) in the acquisition of new data and the advancement of scientific knowledge.

A V-2 stands nearly 46 feet tall and has a diameter of five and a half feet. At launching it weighs over 28,000 pounds of which the propellant fuels make up 19,000 pounds and the "empty" rocket less than 7000. The rest, only about one ton or under 8% of the gross weight, is devoted to "payload," *i.e.*, the scientific equipment. As some of the payload consists of now standard radio and radar equipment used primarily for tracking purposes, the weight available for individual special experiments is further reduced. Similarly most of the volume of the missile is devoted to the fuel tanks and other parts of the propulsion system, leaving parts of the war-head and fin sections as the chief areas available to the scientists. With the rapid advances in the development of electronic and optical devices, however, a great deal can now be packed into only a few cubic inches. The increased effectiveness of small space may readily be appreciated when we realize that a standard radio tube in 1930 was almost as large as a whole set

with some of the minute tubes that are currently produced. Thus, with various small nooks and corners made available, a single rocket may carry cosmic ray counters, a solar spectrograph, telemetering equipment for recording (directly or indirectly) rocket skin temperatures, upper air densities, temperatures and ionization measurements, radar and radio devices, cameras for photographing the earth from great heights, and even at times seeds, insects and artificial "meteors." Many of the experiments made have already been described in the *Scientific Monthly*,* notably the N.R.L. investigations of the upper atmosphere, the acquisition of ultraviolet solar spectra and cosmic ray results. The achievement in solar spectroscopy is considered one of the greatest assets to astrophysics of this era, while the determinations of upper air densities and temperatures give satisfactory confirmation of previously published N.A.C.A. "standard atmosphere" values obtained by indirect methods.

In 1937 when Professor M. N. Saha of India was visiting Harvard he wrote a short note in the *Bulletin*† of the observatory on the advantages to astrophysics of a stratosphere observatory, for solving some of the mysteries of stellar spectra. The paper was incited by the proven possibilities of sending radio sonde balloons to an altitude of 40 kilometers. Work of the Regeners had demonstrated that the ozone which absorbs most sun and star light of wave lengths shorter than 2900 angstroms lies mostly between heights of 20 and 35 kilometers, with only one-twelfth above 40 and barely one-fiftieth above 50 kilometers. Observations below λ 2900 are needed to decide between various theories regarding the physical processes responsible for the observed features of the spectra and the solution of various problems of stellar atmospheres.

Saha predicted that from a height of 40 kilometers we should see the solar spectrum down to λ 2000, "and probably no atmospheric bands will appear between λλ 2900 and 2000. Between λλ 2000 and 1700 the Runge-Shumann bands of O_2 may appear in absorption. The region λλ1700-1250 will probably be completely cut off. A strip between λ1250 and λ 1000 may be expected to be transmitted." These predictions have been substantially supported by the spectra obtained by the V-2 "Observatory" on October 10, 1946. The spectrum photographed from 34 kilometers extended to λ 2650, with some light showing between λλ 2100 and 2260 but with strong ozone absorption at about 2550 angstroms. From 55 kilometers, however, there remains very little evidence for ozone absorption. The spectra have a dispersion of about 50 Å/mm and a resolving power of about 3 Å.

Since ultraviolet light is unable to penetrate ordinary emulsions, special emulsions were developed by the Eastman Kodak Co. for re-

*H. E. Newell, Jr., June, 1947; Colonel Leslie E. Simon, July, 1947.
†*H. B.*, 905, March, 1937.

cording these spectra. The new film has a fluorescent coating which glows when ultraviolet light strikes it. It is the glow that is registered.

Solar spectroscopy from a V-2 is a bit handicapped by the roll and yaw of the missile, which has prevented good records from being obtained from the higher altitudes. Reverting to our space ship problem, we can humorously offer higher hopes for the rather distant future. Addressing the American Psychiatric Association in May, 1946, Dr. Harlow Shapley suggested that given enough money and time a radio-equipped rocket-controlled projectile could be sent a few thousand miles above the earth. Once there and started in the right direction it would continue to travel around the earth under the influence of gravity alone —*i.e.*, a man-made satellite to the earth, and a first rate solar observatory if we can manage to operate it!

Another experiment which inspired astronomers with high hopes was unfortunately not successful, namely, the one involving artificial meteors. Since the V-2 rocket traverses the regions in which most meteors and fireballs appear, particles ejected at high velocities from the rocket should simulate real meteors. Moreover, certain features of the artificial meteors should be subject to a sufficient degree of control so that the artificial meteors might serve as a type of "calibration" for true meteors. For example, the artificial meteors (produced by shaped charges with metallic liners) should have a known range of sizes, a predetermined composition, and their velocities could be accurately measured by multiple-camera meteor-photography techniques. Hence an experimental mass-velocity-luminosity relationship could be determined. In addition, the measured decelerations of these particles should yield valuable information on upper air densities. For the initial experiment California Institute of Technology and Johns Hopkins University collaborated on the program and instrumentation in the missile. Harvard also stood by with new accurate meteor cameras with rotating shutters (30 rps) for velocity and deceleration determinations. Swarms of meteors were to be ejected at various altitudes from 30 to 50 miles. But the grenades that were to produce the artificial meteors on the night of December 17, 1946, unaccountably failed to function. It is, however, hoped that in the future such experiments will be conducted successfully. Indeed Dr. Fritz Zwicky, who was most responsible for planning this program, hoped that an artificial meteoroid weighing under a pound might actually leave our atmosphere, since he anticipated that velocities exceeding 50,000 feet per second (or ten times the maximum velocity of the rocket itself) might be achieved. In fact Dr. Zwicky has out-raced others in speculation. If such V-2 ejected meteoroids, or else a swarm or jet of parallel-moving particles, do ever wander away from the Earth, and he is confident that we shall have such terrestrial-meteoroids before we have rocket space ships, (*cf.*, *Ordnance*, July-August, 1947) then, he predicts, we shall be able to see the flash of their impacts if they strike the moon (or perhaps

even another planet). This, says Dr. Zwicky, "opens up the possibility of direct spectroscopic prospecting of the surfaces of the planetary bodies."

The V-2 rockets and other high altitude missiles are thus the Santa Maria, Pinta, and Niña of modern exploration. Those little 50-100 ton vessels in 1492 spanned a mighty ocean in quest of an expected but previously unproven goal, thereby opening up a vast unknown continent for exploration and exploitation. Similarly these new rockets, as yet piloted only by remote control (if any), are seeking specific goals in the confirmation of man's theories on cosmic rays, atmospheric structure, solar constitution, as well as engineering performance, meanwhile opening up wide fields for further scientific exploration, to be exploited by engineering ability. As yet we still discourage would-be passengers on these pioneering explorations into space. But we do add a note of hope. Fruit flies taken along on one of the V-2 express flights to a high altitude were returned by slow parachute, unharmed, it is said, by the high accelerations they had experienced.

On the Photometry of Double Stars

By ÅKE WALLENQUIST

1. *Introduction.* The photometry of double stars constitutes that branch of astronomical photometry which has as its object the determination of photometric data of the components in binary systems. At present the measurement of the differences in magnitude between the components is of main interest among observers. As is well known, there are from the observational point of view three groups of binaries, *viz.*, spectroscopic, photometric, and visual binaries. Only the photometry of visual binary stars will be treated in this paper.

Ever since the time of William Herschel double stars have been the object of careful study. The interest of the observers has, however, primarily been concerned with the dynamical properties of the systems and, consequently, they have tried to determine as accurately as possible the positions of the components, whereas the physical data of the systems have been generally disregarded. Thus, the difference in magnitude was only roughly estimated and this quantity was given merely as a by-product of the astrometric work, and was designed as a means of identificaton of the system.

As a matter of fact, the pure photometry of double stars has, until recent years, been a fairly neglected field of research, omitting for the moment the magnificent pioneer work of E. C. Pickering and his collaborators at the Harvard Observatory.[1,2,3] Photometrically determined differences in magnitudes can in reality be found for only about 10% of all known systems. The main reason for this state of affairs is

probably to be found in the many difficulties which present themselves within this special branch of photometry. These difficulties arise chiefly from the small apparent distances between the components: only in exceptional cases does the angular separation between the components exceed 30″, and they are generally below 5″.

If the differences in magnitude are not too large and the separations are, say 10″-20″ or more, then in most cases it will be possible to employ ordinary photometric methods—photographic or perhaps even photoelectric—and we can, consequently, determine magnitude differences of the highest degree of precision within the reach of modern photometry.

2. *Photographic methods.* As a rule, the photographic determination of magnitude differences in double stars demands instruments of large focal-lengths. But in this case also, the results obtained for close pairs may be influenced systematically by various photographic effects, due to the mutual action of adjacent photographic images, *e.g.*, the turbidity-effect, the Eberhard-effect, etc. In order to avoid such errors as far as possible, the free space between the two images in the double star must be at least 0.1 mm on the photographic plate. This fact sets an inferior limit of distance to the applicability of photographic photometry of double stars.

It is also advisable to make the exposures through a suitable color-filter that absorbs all uncorrected light from the objective which, as an aureole, surrounds the focal image of the star. In the case of a bright primary with an adjacent faint companion it may actually happen that the image of the component is reproduced on that part of the plate which is affected by the diffuse uncorrected light of the primary. This acts as a kind of pre-exposure and may, consequently, introduce systematic error in the magnitude determination.

In the case of photographic magnitude differences, the magnitude scale can be established most conveniently by means of coarse gratings placed in front of the objective. On account of the properties of the photographic plates, only fairly small differences in magnitudes—scarcely larger than 4-5 magn.—can, however, be successfully measured in this way.

For the reasons mentioned above the photographic method must generally be restricted to wide pairs and to pairs with small differences in magnitude. On the other hand, since a large number of exposures can be easily secured on the same plate, the internal accuracy achieved in the final result is always very high. The mean error in the photographic differences in magnitudes measured at Leiden was, *e.g.*, only $\pm$ 0.030 magn.[4]

An indirect method of determining photographic magnitude differences of close double stars which are not separated will be mentioned in this connection. In this method, proposed by Harold L. Alden,[5] a series of images with varying exposure times is made of

the double star in such a manner that with the shorter exposures only the light of the primary is registered on the plate and with the longer exposures the combined light of the components produces the images. From the measurements of the images of the primary (the shortest exposures) as well of those of the combined light (the longest exposures) the differences in magnitudes may be derived by a simple calculation. When the difference in magnitude is 3 magn., or more, however, it will not be possible to determine this quantity with any degree of accuracy and the method will accordingly fail.

The most accurate of the impersonal methods used in modern astrophotometry, the photoelectric method, has not yet played any rôle in the photometry of double stars. In this case too the small distances between the components cause the main difficulties which must be overcome.

In summing up, we have seen that the use of impersonal methods —photographic or photoelectric—in the photometry of double stars are, despite their superiority to visual methods, restricted to wide pairs and pairs with small differences in magnitudes. For general cases, therefore, we are still largely forced to rely on purely visual methods.

3. *Visual photometry.* Generally speaking, all visual photometers in common use may be employed in the photometry of double stars.[6,6a] Since it is not possible to obtain an artificial comparison star which closely resembles an ordinary star in color and general appearance, those types of photometers may be preferred which do not make use of an artificial comparison star. The most convenient methods are undoubtedly those in which the observations can be arranged in such a manner that it is possible to make direct comparisons of the brightnesses of the components of the systems with one another. In this case the images to be compared are almost exactly alike, and they are compared under identical conditions. Moreover, defects due to the telescope, imperfectness in the driving clock, haze, or even driving clouds, affect both images equally. Therefore, this kind of observation can also be made under weather conditions that would render other photometric observations impossible.

Hitherto two fundamentally different methods have been used in this photometry: one is based on the photometry of equality, the other is based on the use of gratings.

The grating method was originated by G. P. Kuiper.[7] He employed various objective gratings with increasing values of the differences in magnitude between the central and the first-order images. In addition, the gratings were given such dimensions that the first-order spectra were starlike in shape. When making observations a grating was chosen in which the first-order image of the bright companion had approximately the same brightness as the central image of the faint companion. The small differences in magnitude between these two images were then estimated.

By this method it was possible to measure pairs with large differences in magnitude without any noteworthy loss of light, and the mean error of a single measurement was generally smaller than ±0.17 magn.

Kuiper's method has many advantages: the magnitude scale is of a fundamental character—based on the properties of the gratings—and both images are seen against the same background and are identical in shape. The main disadvantage is that the distance between the images to be compared cannot be varied, a fact which may frequently introduce a systematic error due to distance. The repeated changing of gratings may also be somewhat troublesome and a valuable improvement to the method would be the construction of an objective grating with variable grating constant.

The method of photometry of equality has been used mainly at the Harvard (*loc. cit.*) and the Uppsala Observatories.[8,9,10,11] Observations have also been made at the observatories at Illinois,[12] La Plata[11] and Leipzig.[13] The underlying principle of this method is to reduce in a measurable way the brightness of the primary star by means of a suitable photometric device until equality is reached with the brightness of the companion.

In the Harvard photometry the reduction of brightness was performed on the basis of the principles of the polarization of light. Several visual photometers have been devised by Pickering. The most useful of them for the photometry of double stars was the "Photometer H," in which a double-image Rochon prism formed two images of each star.[1] By rotating a Nicol prism placed between the eyepiece and the eye, the intensity of the images could be varied. This was done until the faint image of the bright component appeared exactly equal in intensity to the bright image of the fainter component. By turning the photometer and moving the Rochon prism along the axis of the telescope the distance and positions of the two images under consideration could be varied within wide ranges. The mean error of a single measurement was about ±0.24 magn.

Quite recently J. Hopmann employed a similar method in Leipzig.[13] Instead of a Rochon prism as polarizor he used a polarizing filter from Zeiss.

The principal advantages of this method are that the magnitude scale depends on the fundamental laws of the polarization of light. Moreover both images are seen on the same background and they are exactly alike. Since it is possible to arrange the observations in such a manner that the distances between the images may be kept constant, no distance error is introduced, which is a very important thing with this kind of measurement.

In the method used at Uppsala (and also at La Plata) the light of the brighter component was reduced by means of a neutral absorbing wedge until equal intensity with the fainter component was reached. In most cases the wedge was an ordinary absorption wedge of neutral

tinted glass which covered one half of the field of view but left the other half free. Since the thickness of the wedge limits the measurable distances, a photographic wedge was also used in the case of narrow pairs. When using a photographic wedge the optical path of the free field of view and that part covered by the wedge could easily be made identical by copying the wedge on one half of the plate and leaving the other clear.

During the observations the photometer was turned in position until the bright companion was completely covered by the wedge. Then the wedge was moved perpendicularly to the line joining the stars until equality in brightness was secured, when the position of the wedge was noted. These observations are very easy to perform and it is possible to measure about 20 or more stars in an hour.

The principal advantages of this method are that the shape of the images to be compared are identical and there is no need to use an artificial comparison star. The principal disadvantage of the wedge-method is that the magnitude scale is entirely dependent on the properties of the wedge. The absorption curve of the wedge must, accordingly, be very accurately determined. Besides systematic errors depending on the angular separation between the two components, the color of the stars, their mutual position, the intensity of the background, etc., may also influence the magnitude determinations. The mean error of one observation is about ± 0.20, but the accuracy decreases in this as in other visual methods with increasing distance as well as with the increasing value of the magnitude difference.

By means of the visual methods dealt with here, it is hardly possible to obtain results of the same accuracy as those that can be achieved by means of the photographic methods during favorable conditions. Even if the internal mean error turns out to be fairly small, experience has shown that the external error is always large. When comparisons with other observers are made, mean deviations amounting to 2 or 3 times the internal mean error may be expected. (This is also generally the case when comparisons are made between different observers in ordinary photometry.) The only way to increase the accuracy in the magnitude determinations at the present moment seems to be by repeated observations. Therefore, it would be very desirable if photometric observations of double stars could be carried out at several observatories. By means of cooperation in the field of the photometry of double stars in the same manner as earlier in the field of position astronomy, it should be possible within a few years to get photometrically measured magnitude differences of high accuracy for most of the known double star systems.

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[9] Åke Wallenquist, *Ibid.*, No. 87, 1944.
[10] Åke Wallenquist, *Uppsala Annaler*, Band 2, No. 2, 1947.
[11] Åke Wallenquist, *Ibid.*, Band 2, No. 3, 1948.
[12] J. Stebbins, *University of Illinois Bull.*, Vol. IV, No. 25, 1907.
[13] J. Hopmann, *Zeitschr. für Astroph.*, Band 24, p. 263, 1948.

NOTE ADDED IN PROOF

After this paper was written an important investigation, "Measures Photométriques d'Étoiles Doubles," was published by P. Muller (*Annales de L'Observatoire de Strasbourg*, Tome V:1, 1948). In his paper Muller describes an improved polarization photometer of the Pickering type, by means of which visual differences in magnitudes for 70 double stars have been measured with extreme accuracy, the internal m.e. being ±0.041 magn. only.

THE ASTRONOMICAL OBSERVATORY, UNIVERSITY OF UPPSALA, SWEDEN,
MAY 13, 1948.

Messier's Catalogue

By PAUL S. WATSON

The catalogue of 103 clusters and nebulae, compiled by the French astronomer, Charles Messier, in 1781 to assist him in identifying new comets, is still an excellent list of objects for the possessor of a small telescope. It contains 33 extragalactic nebulae, 30 open clusters, 27 globular clusters, 6 diffuse nebulae, and 5 planetary nebulae. Two objects listed, M 40 and M 91, are no longer found and must have been errors of some sort. Very few popular works on astronomy give the complete Messier list, and furthermore, some popular atlases use the Messier system, others the N.G.C. number (the New General Catalogue of J. L. E. Dreyer published in 1890).

For this reason the complete Messier Catalogue with the positions corrected for the epoch of 1950, together with the corresponding N.G.C. numbers was prepared for the Astronomical Section of the Maryland Academy of Sciences and is given below.

The 1950 positions of all extragalactic nebulae have been taken from "A Survey of the External Galaxies Brighter than the Thirteenth Magnitude" by Shapley and Ames (*Harvard Annals*, **88**, No. 2), the epoch of which is 1950. The positions of all the other objects, except as noted below, have been taken from the New General Catalogue of Dreyer and corrected to 1950.

M 25 is not listed in the N.G.C. but is found in Dreyer's Second Index Catalogue, number I 4725. M 40 and M 91 can no longer be found and both were probably errors on Messier's part or they may

have been comets which have long since gone their way. M 45, the Pleiades, and M 48 in Hydra are not found in either the N.G.C. or Index Catalogue probably because these clusters are too open and coarse. For the sake of completeness the positions of these objects have been brought forward to 1950.

The last column in the list gives a brief description. If the object has a special name, this is listed, otherwise just the class of type or object is given. The following abbreviations are used in the first case: Pl—planetary nebula, Cl—cluster, Neb—nebula, Dif—diffuse nebula, Op Cl—open cluster, XG—extragalactic nebula or external galaxy.

Additional copies of this catalogue may be obtained without charge from the Maryland Academy of Sciences, 400 Cathedral Street, Baltimore 1, Maryland.

Messier No.	N.G.C.	Constellation	R.A. (1950.0) h m		Dec. (1950.0) ° ′		Description
1	1952	Taurus	5 31.5	N	21 59		Crab Nebula (Pl)
2	7089	Aquarius	21 30.9	S	1 4		Globular cluster
3	5272	Canes Venatici	13 39.9	N	28 38		" "
4	6121	Scorpius	16 20.5	S	26 24		" "
5	5904	Serpens	15 15.9	N	2 16		" "
6	6405	Sagittarius	17 36.8	S	32 11		Open cluster
7	6475	"	17 50.5	S	34 48		" "
8	6523	"	18 00.6	S	24 23		Lagoon Nebula (Cl & Neb)
9	6333	Ophiuchus	17 16.2	S	18 30		Globular cluster
10	6254	"	16 54.5	S	4 2		" "
11	6705	Aquila	18 47.3	S	6 20		Open cluster
12	6218	Ophiuchus	16 44.6	S	1 51		Globular cluster
13	6205	Hercules	16 39.9	N	36 33		" "
14	6402	Ophiuchus	17 35.0	S	3 10		" "
15	7078	Pegasus	21 27.6	N	11 57		" "
16	6611	Serpens	18 16.0	S	13 48		Open cluster
17	6618	Sagittarius	18 18.0	S	16 12		Horseshoe Nebula (Dif)
18	6613	" "	18 16.9	S	17 9		Open cluster
19	6273	Ophiuchus	16 59.5	S	26 11		Globular cluster
20	6514	Sagittarius	17 59.3	S	23 2		Trifid Nebula (Dif)
21	6531	"	18 01.5	S	22 30		Open cluster
22	6656	"	18 33.3	S	23 57		Globular cluster
23	6494	"	17 54.0	S	19 1		Open cluster
24	6603	"	18 15.5	S	18 26		" "
25	I 4725	"	18 28.7	S	19 17		" "
26	6694	Scutum	18 42.6	S	9 28		" "
27	6853	Vulpecula	19 57.4	N	22 35		Dumb-bell Nebula (Pl)
28	6626	Sagittarius	18 21.4	S	24 54		Globular cluster
29	6913	Cygnus	20 22.1	N	38 22		Open cluster
30	7099	Capricornus	21 37.6	S	23 23		Globular cluster
31	224	Andromeda	00 40.0	N	41 0		Great Nebula (XG)
32	221	Andromeda	00 39.9	N	40 36		External Galaxy*
33	598	Triangulum	1 31.0	N	30 24		" "
34	1039	Perseus	2 38.7	N	42 35		Open cluster
35	2168	Gemini	6 05.7	N	24 21		" "
36	1960	Auriga	5 32.7	N	34 6		" "
37	2099	"	5 49.0	N	32 33		" "

*Faint companion to M 31. N.G.C. 205 is another companion, though six magnitudes fainter than M 31.

Messier No.	N.G.C.	Constellation	R.A. (1950.0) h m		Dec. (1950.0) ° ′		Description
38	1912	"	5	25.3	N 35	48	" "
39	7092	Cygnus	21	30.5	N 48	13	" "
40	—	Ursa Major	12	19.8	N 58	31	*Error.*[1]
41	2287	Canis Major	6	44.9	S 20	42	Open cluster
42	1976	Orion	5	32.5	S 5	25.	Great Nebula (Dif)
43	1982	"	5	32.9	S 5	18	Small Nebula (Dif)
44	2632	Cancer	8	37.2	N 20	10	Praesepe (Op Cl)
45	—	Taurus	3	44.5	N 23	58	Pleiades (Op Cl)
46	2437	Puppis	7	40.0	S 14	42	Open cluster
47	2478	"	7	52.4	S 15	2	" "
48	—	Hydra	8	11.5	S 1	47	" "
49	4472	Virgo	12	27.2	N 8	16	External Galaxy
50	2323	Monoceros	7	00.6	S 8	20	Open cluster
51	5194	Canes Venatici	13	27.8	N 47	27	Whirlpool Nebula (XG)
52	7654	Cassiopeia	23	22.1	N 61	20	Open cluster
53	5024	Coma Berenices	13	10.5	N 18	26	Globular cluster
54	6715	Sagittarius	18	51.9	S 30	32	" "
55	6809	"	19	36.8	S 31	4	" "
56	6779	Lyra	19	14.6	N 30	5	" "
57	6720	"	18	52.0	N 32	58	Ring Nebula (Pl)
58	4579	Virgo	12	35.1	N 12	5	External Galaxy
59	4621	"	12	39.5	N 11	55	" "
60	4649	"	12	41.1	N 11	50	" "
61	4303	"	12	19.4	N 4	46	" "
62	6266	Scorpius	16	58.0	S 30	2	Globular cluster
63	5055	Canes Venatici	13	13.6	N 42	18	External Galaxy
64	4826	Coma Berenices	12	54.3	N 21	57	" "
65	3623	Leo	11	16.3	N 13	22	" "
66	3627	"	11	17.6	N 13	16	" "
67	2682	Cancer	8	48.5	N 12	0	Open cluster
68	4590	Hydra	12	36.8	S 26	28	Globular cluster
69	6637	Sagittarius	18	28.0	S 32	23	" "
70	6681	"	18	39.9	S 32	20	" "
71	6838	Sagitta	19	51.5	N 18	39	Open cluster
72	6981	Aquarius	20	50.7	S 12	44	Globular cluster
73	6994	"	20	56.0	S 12	49	Open cluster
74	628	Pisces	1	34.0	N 15	32	External Galaxy
75	6864	Sagittarius	20	03.1	S 22	4	Globular cluster
76	650	Perseus	1	38.3	N 51	20	Planetary nebula
77	1068	Cetus	2	40.1	S 0	14	External Galaxy
78	2068	Orion	5	44.1	N 0	3	Diffuse nebula
79	1904	Lepus	5	22.1	S 24	34	Globular cluster
80	6093	Scorpius	16	14.0	S 22	53	" "
81	3031	Ursa Major	9	51.5	N 69	18	External Galaxy
82	3034	"	9	51.8	N 69	58	" "
83	5236	Hydra	13	34.2	S 29	36	" "
84	4374	Virgo	12	22.5	N 13	9	" "
85	4382	Coma Berenices	12	22.9	N 18	28	" "
86	4406	Virgo	12	23.7	N 13	13	" "
87	4486	"	12	28.3	N 12	40	" "
88	4501	Coma Berenices	12	29.5	N 14	42	" "
89	4552	Virgo	12	33.1	N 12	50	" "
90	4569	"	12	34.3	N 13	26	" "
91	—	"	12	38.5	N 13	33	*Error.*[1]
92	6341	Hercules	17	15.6	N 43	12	Globular cluster
93	2447	Puppis	7	42.5	S 23	45	Open cluster
94	4736	Canes Venatici	12	48.6	N 41	24	External Galaxy
95	3351	Leo	10	41.3	N 11	58	" "
96	3368	"	10	44.1	N 12	5	" "

Messier No.	N.G.C.	Constellation	R.A. (1950.0) h m		Dec. (1950.0) ° ′		Description
97	3587	Ursa Major	11 11.8	N	55 17		Owl Nebula (Pl)
98	4192	Coma Berenices	12 11.3	N	15 11		External Galaxy
99	4254	"	12 16.3	N	14 42		" "
100	4321	"	12 20.4	N	16 6		" "
101	5457	Ursa Major	14 01.4	N	54 35		" "
102	5866	Draco	15 05.1	N	55 57		" "
103	581	Cassiopeia	1 29.9	N	60 26		Open cluster

MARYLAND ACADEMY OF SCIENCES, BALTIMORE, JUNE 27, 1948.

A New Type of Magnetometer Survey at Barringer Meteorite Crater

By H. H. NININGER

Surprisingly little research of a purely scientific nature has been recorded concerning the world's greatest known meteorite crater. Even after 57 years have elapsed since its discovery, we still know practically nothing about this outstanding example of cosmo-terrestrial collision other than the facts recorded by those who attempted to exploit it commercially.

Recent drilling of water wells in the vicinity makes it fairly certain that the water which was encountered in the crater by those who attempted to develop a mine during the early years of this century is not merely an accumulation of rainfall within the pit; it marks the water table of the region. Therefore, any hope of extensive explorations within the pit for the purpose of securing satisfying information seems pretty remote.

Dr. Barringer and his associates have left for us fairly complete information as to the structure of the crater and the nature of its terrestrial contents. Also, they proved a fairly general distribution of meteorite fragments of unknown size in its depths. These facts, together with the proven abundance of meteorite fragments around it, leave no reason for question as to its impact origin.

We have for some years believed that the most fruitful source of further information regarding the nature of the cosmic encounter, which was responsible for this important geological feature, lies in an adequate knowledge of the horizontal and vertical distribution of the various-sized meteorite fragments around it.

With this as our objective and with the help of contributions from the American Philosophical Society and certain individual donors, we carried on a search some years ago for small fragments at the surface of the ground by means of a magnetic rake. The results of this search pointed to a radial distribution of this material from the crater pit; but funds were not sufficient to carry the investigation far enough to justify any final conclusions.

Much yet remains to be done before our knowledge of these small fragments is complete, but the larger fragments present an equally important aspect of distribution. Unfortunately, a great deal of collecting has been done, of which no record has been kept. Through the years the custom developed of hunting when and where anyone wished and the rule was "finders keepers."

The map prepared by Holsinger and Barringer in 1909 was an attempt to show the distribution of finds up to that time. But so far as is known no record has been kept subsequently.

About 1929, collecting by means of detectors was begun. Again, no records were kept but this type of collecting usually involved more or less of digging so that some knowledge can be gained of the number of finds by an inspection of the holes left although in certain locations holes are quickly filled by the blowing of sand. In other locations, especially on the upper half of the rim slope, digging often involved the upturning of rocks, the lower sides of which are usually encrusted by a deposit of $CaCo_3$. This coating, after a few rains shows conspicuously white and often betrays the location where finds were made even though no hole remains.

Barringer recorded in 1909 that the northeast section of the rim yielded "thousands" of small metallic fragments ranging from less than an ounce to 5 pounds. The word "thousands" is rather indefinite and I often wondered just what was its significance. Talking to various "old Timers" I was given the impression that there must have been many thousands of these small irons.

When the American Meteorite Museum was opened and we began a detailed investigation of the rim on a permit from the Barringers, we hoped to be able to find enough of the left-overs during the years ahead and to gain sufficient knowledge of the amount and locations of previous finds to throw some light on Dr. Barringer's statement regarding "thousands" of small fragments on the northeast sector of the rim.

We obtained from the Barringers and from the Cattle Company who own much of the land surrounding the Barringer property, permission to search for specimens with the understanding that our finds would all be mapped and would be made a basis for continued study of the distributional problem.

Our feeling was that the yield would be slight, but that, by noting its relation to the workings of past years as indicated by the evidences of digging, we should be able to gain at least a general idea of the relative original abundance and that this would tie in with the other types of surveys which we proposed. Altogether it would, we thought, be far more meaningful than the haphazard, unsupervised, and unreported collecting that characterized the previous three decades had been.

We were given, by both the Barringers and the Cattle Company, the authority to say by whom and where collecting could be done with

the understanding that all finds be reported. The policy which we adopted was to let any interested party, particularly scientists, hunt for meteorites, upon request. For use on the surveyed portions of lands lying outside the Barringer property, forms were printed dividing the General Land Office square mile surveys into 20-acre plats. On these were to be recorded all finds, which records would be filed as supplements to the records of finds made by our staff.

The work on the rim itself was to be, and is now being recorded on a large scale map drawn from a survey of various aerial photographs and correlated with our ground survey.

Until the present month, our search was limited to the crater rim. Frankly, we were not prepared for the yield of meteorites that we have witnessed during the past year. We had supposed that finds would be relatively scarce. Actually, however, we have been able to record more than 5000 finds during the year on the northeast sector of the crater rim. These were made by members of our own staff, by visiting scientists, and other interested parties who came to the museum and who wished to have the thrill of finding a meteorite. No one who came was ever refused permission and it was grand fun to witness the enthusiasm of veteran astronomers, geologists, and other scientists on the occasion of their first find.

Unfortunately, we are not able to report that our records are complete. Commercial hunters are known to have searched without permission and made no report of their finds. Other individuals have been reported seen working at various times and consequently the over-all picture is not what would be desired by scientists interested in seeing a more adequate and useful fund of knowledge collected concerning the world's most perfect meteorite crater.

The results are not without significance, however, and several definite conclusions may be eventually arrived at as the search continues through the years.

Our search was made with standard army surplus mine detectors working effectively to a depth of only about 10 inches on the average specimens. The larger specimens could be detected at somewhat greater depth, but never more than 2 feet.

Because of the abundance of large rocks and shrubbery, we estimate that only 70 per cent of the surface was accessible to the instrument. Inefficiencies of operation, such as incomplete coverage and defective instrumentation, probably brought the efficiency down to about 50 per cent. Comparing the number of diggings made by us with those which had been made previously and were still visible, we concluded that probably five times as many had been dug out in past years as were found by us. If we assume that the "thousands" referred to by Barringer amounted to about the same number as the 5000 which were recovered under our observation and we add five times as many to cover the collecting between 1929 and 1947, then we arrive at 30,000 plus

5000 which equals 35,000 specimens from the northeast quarter of the upper half of the rim.

It is hardly probable that this estimate is too large and it is quite possible that it is much too low, because it seems likely that many of the older diggings had been completely obliterated. Veteran local collectors referred to certain areas as "the diggins" where they say it was always possible to find small specimens.

Assuming the same average size as we have found in our collecting we obtain a weight of approximately 18,000 pounds, or 9 tons. Bear in mind that this survey was limited to a section extending from about the middle point on the east rim to the middle of the north rim. It must not be assumed that the same density of distribution would be found on other portions of the rim. The records have always shown a greater abundance of fragments on the northeast portion than on other sections of the rim.

We are now beginning a new type of survey designed to reveal any sizable fragments which may lie below the reach of the various types of detectors that have been used in the search that has been going on in the region during the past 20 years. All of the large fragments so far reported have been found within less than four feet of the surface and all but a very few were within a few inches or even at the surface. This condition is totally inconsistent with what has been learned from witnessed falls where similar-sized specimens, even of stony meteorites have buried themselves to depths up to 14 feet at the time of fall. Our supposition is that these surface specimens have all been blown out of the crater by an explosion connected with the impact and, further, we believe that if any meteorites accompanied the main crater-forming mass from space, they will be found at considerably greater depths. We believe that a search will reveal a deposit of such masses and that it may possibly reveal subsidiary craters that have been subsequently completely filled, either by erosion or by ejecta from the main crater at the time of the latter's formation.

Experiments with a magnetometer indicated that a 100-lb. meteorite could be detected at a distance of 21 feet. Consequently, we developed a plan of survey consisting of traverses 30 feet apart and of stations every 30 feet in these traverses. When a station gives unusually high or unusually low reading, the operator sets up stations on various sides at distances of 5, 10, or 15 feet until he ascertains whether there is a worthwhile anomaly, in which case he covers the affected area with stations at 5-foot intervals, or less.

The survey has been in progress 21 days during which we have recorded readings from about 900 stations. Although no excavations have been made, several anomalies have been found and mapped so that in the near future we shall begin testing them by boring and excavations.

If the testing of these anomalies proves as gratifying as has the in-

strumentation, then we have a program ahead of us that should furnish much information which should prove of value in determining the true nature of the collision which produced the famous landmark that has been the subject of so many disputes during the last half century.

Our present effort is by way of a preliminary test of the survey plan described above. Funds for this test have been supplied by two private donors and the American Philosophical Society. Once the fruitfulness of the method has been demonstrated, it is hoped that funds sufficient to carry the survey for at least two years can be secured. Such a period would enable us to cover about two square miles, which in properly selected locations should allow for some important deductions regarding the frequency of sub-soil intrusions in the area.

American Meteorite Museum, Box 1171, Winslow, Arizona.

Planetary Phenomena in 1949

By PAUL S. WATSON

Graphic Time Table of the Heavens

This is a condensed and simple almanac in graphic form published annually by the Maryland Academy of Sciences, Baltimore. It gives the rising and setting times of the Sun, Moon, and brighter planets, the beginning of morning twilight and the ending of evening twilight, the times when the visible planets and certain other objects of particular interest cross the meridian, occultations of bright objects by the Moon, and other useful astronomical information.

It is computed for 40° north latitude and 90° west longitude (6 hours west of Greenwich), and is therefore correct for only this point on the Earth, but it can be used to advantage anywhere in the United States, provided the user, wherever he is, make correction for the distance he may be from his own particular time meridian. The corrections for a number of important cities are listed below:

Atlanta	+38 min.	Memphis	0 min.
Baltimore	+ 6 min.	Milwaukee	— 8 min.
Birmingham	—13 min.	Minneapolis	+13 min.
Boston	—16 min.	New Orleans	0 min.
Buffalo	+15 min.	New York	— 4 min.
Chicago	—10 min.	Oklahoma City	+32 min.
Cincinnati	+38 min.	Philadelphia	+ 1 min.
Cleveland	+27 min.	Pittsburgh	+20 min.
Denver	0 min.	Rochester	+10 min.
Detroit	+32 min.	Salt Lake City	+28 min.
Helena	+28 min.	San Francisco	+10 min.
Houston	+22 min.	Santa Fe	+ 4 min.
Indianapolis	—16 min.	Seattle	+10 min.
Kansas City	+18 min.	St. Louis	+ 1 min.
Los Angeles	— 7 min.	Washington	+ 8 min.

(Note: Places for which the correction is minus are east of the standard time meridian, and therefore all events, with the exception of eclipses and occultations, will be earlier by the amount stated. All places with plus correction are west and therefore these events occur later.

For most events, such as the rising and setting of the planets, it

makes practically no difference what standard time meridian in the United States is used. For moonrise and moonset, however, the times shown are correct for the 90th meridian. For the 75th, 2 minutes should be subtracted, while for the 105th and 120th, 2 and 4 minutes, respectively, should be added on the average. Certain events, such as eclipses of the Moon and the phenomena of Jupiter's satellites, occur at a specified time regardless of location. In these cases the time is given in Eastern Standard Time and the appropriate correction should be applied for other time belts. For occultations the time given is for Washington, D. C. For other locations consult the *American Ephemeris and Nautical Almanac*.

Correction for difference in latitude is comparatively minor and may in general be neglected.

Separate copies of the Time Table, as here reproduced, may be obtained without charge from the Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral Street, Baltimore 1, Maryland. Blueprints of the original drawing before reproduction, 40 by 27 inches, may be obtained at cost—75c each. A Quebec edition, in French, computed for 47° north latitude and 75° west longitude, is also available without charge.)

Across the top of the Time Table are shown the hours of the night from 4 P.M. to 8 A.M. the next morning. Down the sides is indicated the date, each horizontal line representing a Thursday evening. The dashes on the sunset and sunrise curves aid interpolation on intermediate days. The various curved lines indicate the rising, setting, and transit times of the heavenly bodies.

The phases of the Moon are indicated by the conventional symbols. Thus, the Moon is new on January 28, and sets at 4:45 P.M. (even though invisible). First quarter occurs on the night of February 5-6, when the Moon sets at 12:54 A.M. Full Moon takes place on February 12, when it rises at 4:47 P.M., and last quarter occurs on the night of February 19-20, when the Moon will rise at 1:38 A.M. The small black circles show moonset for the first half of the lunar month, and the small open circles indicate moonrise for the second half of the lunar month. Small squares on planet curves indicate quadrature and half circles, greatest elongation. The "rose" on the curve for Venus indicates when that planet is at greatest brilliancy. Opposition of a planet is shown by the conventional symbol of two joined circles. Roman numerals give Sidereal Time at midnight. The curve down the midnight line indicates the Equation of Time (this is the difference between mean or clock time and apparent or Sun time). When the curve is left of the midnight line, the Sun is fast and arrives at the meridian before 12 o'clock noon, Local Time, by the amount indicated. When the curve is right, the Sun is slow. The small numbers on the left hand side of the Time Table indicate the Julian Day number, of great interest to variable star observers. Thus, the Julian Day, beginning Greenwich Noon, January 1, is 2,432,000 plus 918, or 2,432,918. The diagonal lines running into the midnight line, marked Pleiades, Great Nebula in Orion, Castor, etc., indicate when these objects transit, or are on the meridian, that imaginary line running north and south which divides the sky into its eastern and western halves. Other information on the Time Table is self-explanatory.

Now, the events of the night of January 6-7 can be easily found by following the horizontal line for that date across the page from left to right: The Julian Day number is 2,432,923; the Sun sets at 4:50 P.M.; Mercury sets at 5:53 P.M.; Mars sets at 6:01; evening twilight ends at 6:25; the Pleiades transit at 8:39; Saturn rises at 8:47; the Great Nebula in Orion transits at 10:30; the Moon is at First Quarter and sets 2 minutes after midnight; the curve for the

Equation of Time indicates that the Sun is slow and will not be on the meridian until 6 minutes after 12 o'clock noon, Local Time; Saturn transits at 3:27 A.M.; Venus rises at 5:38; morning twilight begins at 5:44; Jupiter rises at 7:05 and the Sun rises at 7:22 A.M.

The Planets for 1949

Based on the Graphic Time Table of the Heavens, a summary of the interesting planetary events for the year 1949 is given below. For more detailed information reference should be made to the *American Ephemeris and Nautical Almanac,* the principal source of information used in the calculation of the Time Table.

Mercury is seen for only brief periods either just after sunset or before dawn, as indicated by its rising and setting curves on the Time Table. The best time during 1949 to see this sprightly and evasive member of the solar system is for a few days around May 10 as an evening star, and for a few days either side of October 19 as a morning star. Other elongations are indicated.

Venus at the beginning of the year will be a morning star, rising shortly before dawn, but will soon move in towards the Sun to reappear as an evening star during the latter part of April. It will remain an evening star for the rest of the year, but 1949 is an off year for Venus, as the most favorable elongations of the inferior planets occur during the spring. Until the last three months of the year the planet will remain low in the western sky, setting before the end of twilight; but after October 1 Venus will appear higher in the sky each night until November 20, when greatest elongation is reached. Greatest brilliancy occurs on December 26, so Venus will make a beautiful "Christmas Star" in the western sky during the holiday season.

Mars will be an evening star for the first two months of the year but will be too close to the Sun to be well seen. After passing superior conjunction on March 17, the planet will be seen in the morning sky before dawn. On December 12 Mars will rise at midnight. Opposition does not occur until 1950.

Jupiter, the giant planet, will be seen in the morning sky for the first four months of the year. It rises at midnight on May 13 and opposition will take place on July 19. Jupiter will remain an evening star for the remainder of the year, setting about 2 hours after the Sun on December 31.

The circles on the "Jupiter Transit" curve indicate the nights on which occultations, eclipses or transits of one or more of Jupiter's four brightest moons may be seen with a small telescope between the hours of 7 and 11 P.M., E.S.T., 6 to 10 P.M., C.S.T., etc.

Saturn, the ringed planet, begins the year as an evening object, opposition being on February 21. During the spring and early summer the planet will be well placed in the sky, but after the middle of July it will be lost in the evening twilight setting shortly after the Sun. During September, October, and November, Saturn will be in the morning sky. It rises at midnight on December 4 and at 10:30 P.M. on December 31.

As seen with the telescope the rings of Saturn will appear narrow during the year. On January 1 the Earth will be 13° below the plane of the rings but on December 31 only 1° below. Thus, the rings will not be exactly edge-on until 1950, but during the latter part of 1949 will appear as a line becoming progressively thinner.

Uranus, Neptune, and Pluto are not included on the Time Table because

these planets cannot be seen without instrumental aid. Uranus is in the eastern part of Taurus and western part of Gemini during 1949, and comes to opposition on December 24. Neptune is located in Virgo east of Spica. Opposition takes place on April 3. Pluto is in Cancer and is at opposition on February 8.

Eclipses

In the year 1949 there will be four eclipses, two of the Sun and two of the Moon. Only the lunar eclipses will be visible from the United States.

I. A total eclipse of the Moon, April 12-13, 1949, visible in whole or in part, in Europe, Africa, the North Atlantic Ocean, and North and South America. This eclipse will occur during the early evening hours of April 12 as seen from the United States and should be well observed. Totality begins at 9:28 P.M., C.S.T., and ends at 10:54 P.M., C.S.T. The Time Table indicates the various circumstances (in Eastern Standard Time), which are: when the Moon enters the penumbra, when it enters the umbra, beginning of totality, middle of eclipse, end of totality, when the Moon leaves the umbra, and when it leaves the penumbra. Regardless of the observer's location these times are always the same, although it must be remembered that if the observer is in some other time belt he must make allowance for the number of hours difference between his time and Eastern Standard Time.

The circumstances of the eclipse, in Central Standard Time, a 24-hour period beginning at one midnight and ending at the next, are as follows:

	d	h	m
Moon enters penumbra	April 12	19	31.6
Moon enters umbra	12	20	27.7
Total eclipse begins	12	21	28.0
Middle of eclipse	12	22	10.9
Total eclipse ends	12	22	53.8
Moon leaves umbra	12	23	54.1
Moon leaves penumbra	13	0	50.3

II. A partial eclipse of the Sun, visible in Europe, northwest Africa, and the Arctic regions.

The circumstances, in Central Standard Time, are as follows:

	d	h	m	Longitude °	′	Latitude °	′
Eclipse begins	April 27	23	51.8	+ 5	20	+25	15
Greatest eclipse	28	1	48.4	+ 55	56	+62	4
Eclipse ends	28	3	44.5	+165	55	+69	40

The magnitude of greatest eclipse is 0.609 (Sun's diameter = 1.0).

III. A total eclipse of the Moon, October 6-7, 1949, visible in whole or in part in western Asia, Europe, Africa, the Atlantic Ocean, North and South America, and the Arctic and Antarctic regions. This eclipse is quite similar to the one on April 12-13, and will occur early in the evening of October 6 as seen in the United States. Totality begins at 8:20 P.M., C.S.T., and ends at 9:33 P.M., C.S.T. The Time Table gives the various circumstances in Eastern Standard Time.

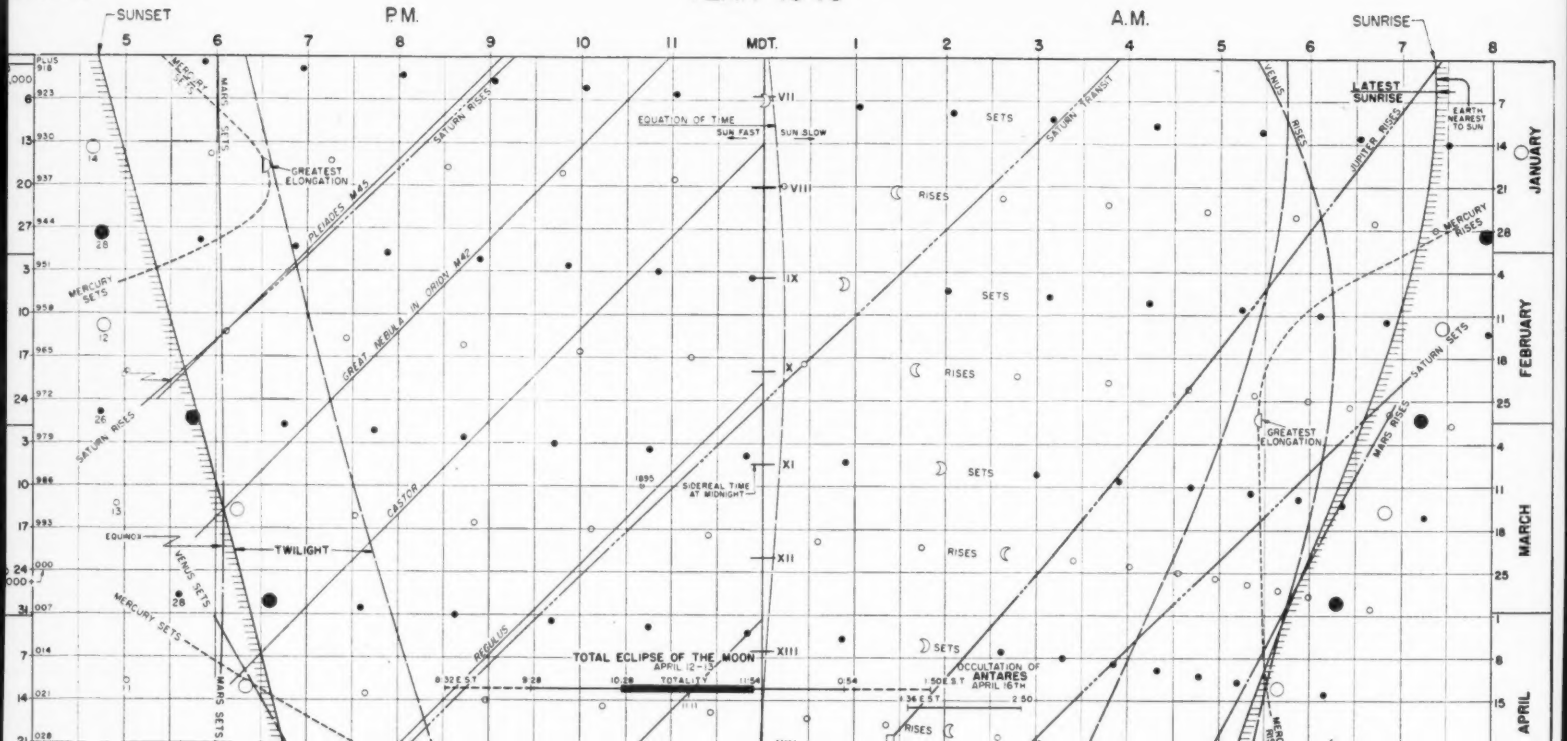
These circumstances, in Central Standard Time, are as follows:

	d	h	m
Moon enters penumbra	October 6	17	50.1
Moon enters umbra	6	19	4.7
Total eclipse begins	6	20	19.5
Middle of eclipse	6	20	56.4

THE MARYLAND ACADEMY OF SCIENCES

GRAPHIC TIME TABLE OF THE HEAVENS

YEAR 1949


DARD TIME
SUNSET
P.M.
A.M.
SUNRISE
MDT.
5
6
7
8
9
10
11
1
2
3
4
5
6
7
8
MERCURY SETS
MARS SETS
SATURN RISES
GREATEST ELONGATION
PLEIADES M45
GREAT NEBULA IN ORION M42
MERCURY SETS
SATURN RISES
CASTOR
EQUINOX
TWILIGHT
VENUS SETS
MERCURY SETS
MARS SETS
REGULUS
EQUATION OF TIME
SUN FAST
SUN SLOW
VII
VIII
IX
X
XI
XII
XIII
SIDEREAL TIME AT MIDNIGHT
1895
TOTAL ECLIPSE OF THE MOON
APRIL 12-13
8.32 E.S.T.
9.28
10.28
TOTALITY
11.54
0.54
SETS
RISES
SETS
RISES
SETS
RISES
SETS
RISES
SATURN TRANSIT
VENUS RISES
JUPITER RISES
LATEST SUNRISE
EARTH NEAREST TO SUN
MERCURY RISES
SATURN SETS
GREATEST ELONGATION
MARS RISES
OCCULTATION OF ANTARES
APRIL 16TH
5.06 E.S.T.
2.50
RISES
MERCURY RISES
JANUARY
FEBRUARY
MARCH
APRIL
PLUS
6
13
20
27
3
10
17
24
3
10
17
24
31
7
14
21
28
1
8
15
22
29
5
12
19
26
3
10
17
24
31
7
14
21
28
4
11
18
25
4
11
18
25
1
8
15
22
29
5
12
19
26
3
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17
24
31
7
14
21
28
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11
18
25
1
8
15
22
29
6
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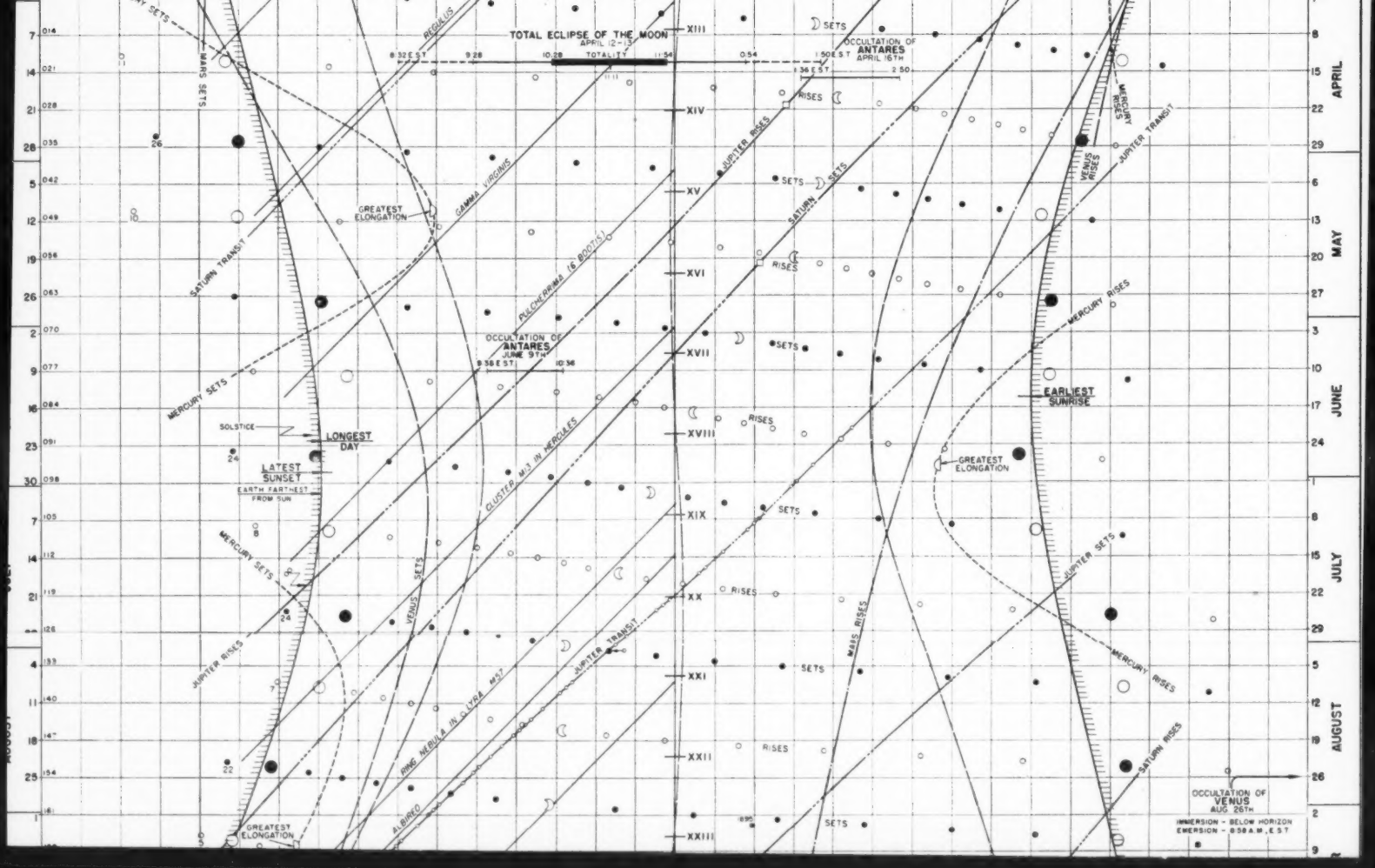
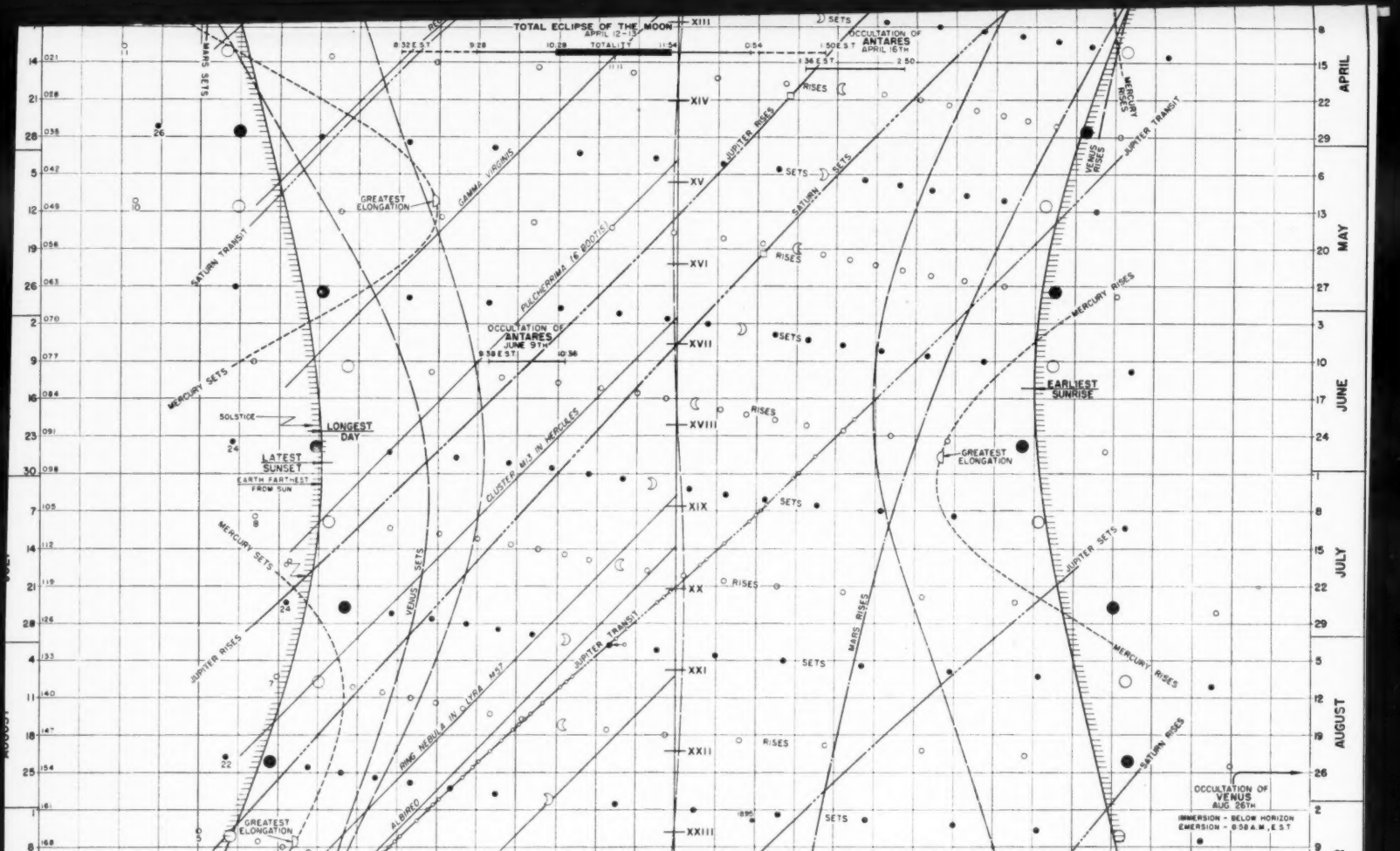
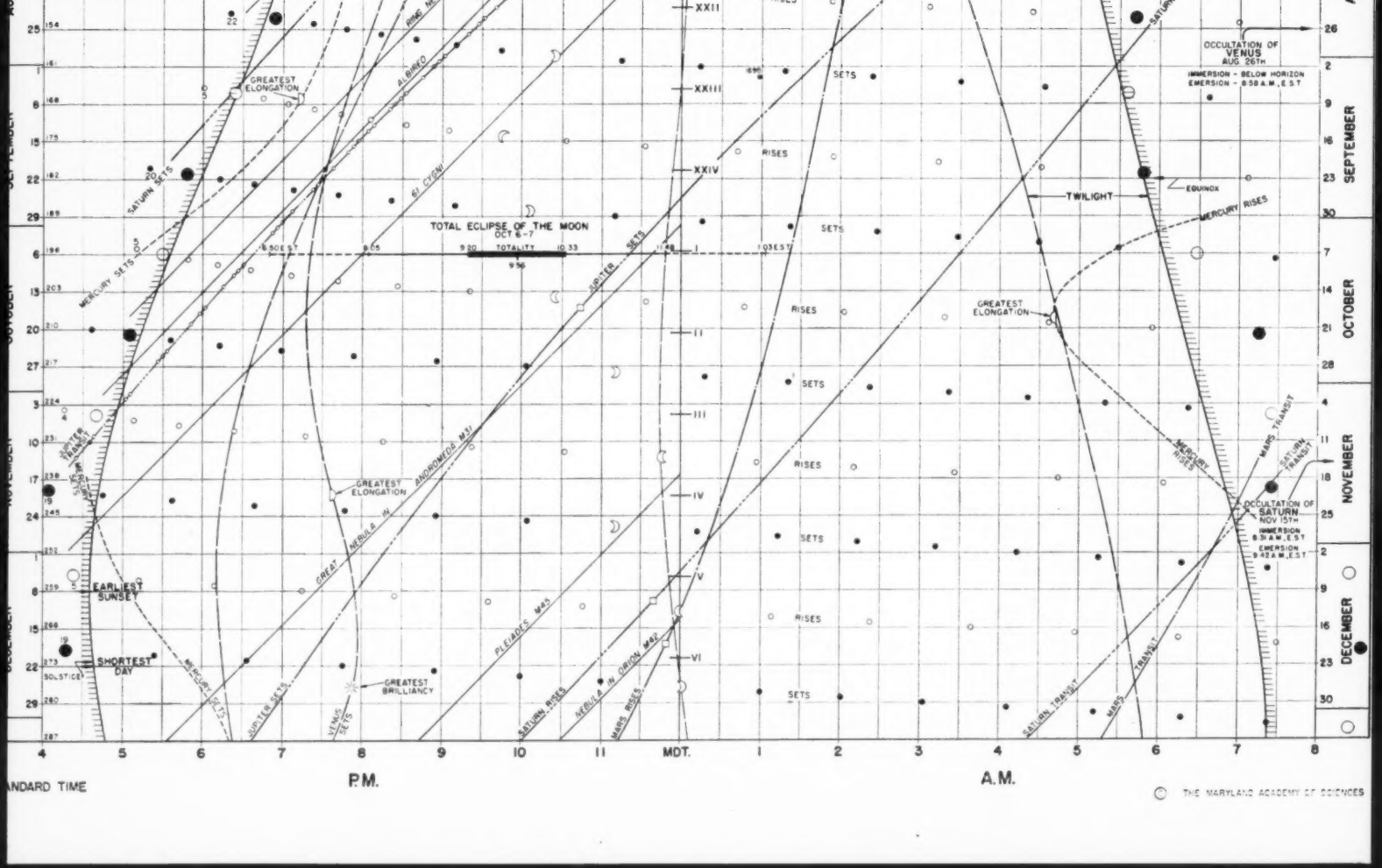
20
27
3
10
17
24


TOTAL ECLIPSE OF THE MOON
APRIL 12-13
8:32 E.S.T.
9:28
10:28
TOTALITY
11:54
0:54
OCCULTATION OF ANTARES
APRIL 15TH
1:36 E.S.T.
1:50 E.S.T.
2:50
REGULUS
MARS SETS
SATURN TRANSIT
GREATEST ELONGATION
GAMMA VIRGINIS
JUPITER RISES
SATURN SETS
PULCHERRIMA (6 BOOTIS)
OCCULTATION OF ANTARES
JUNE 9TH
9:38 E.S.T.
10:56
MERCURY SETS
SOLSTICE
LONGEST DAY
LATEST SUNSET
EARTH FARTHEST FROM SUN
CLUSTER M13 IN HERCULES
VENUS SETS
JUPITER RISES
JUPITER TRANSIT
RING NEBULA IN LYRA M57
ALBIREO
GREATEST ELONGATION
MERCURY RISES
VENUS RISES
JUPITER TRANSIT
EARLIEST SUNRISE
GREATEST ELONGATION
JUPITER SETS
MERCURY RISES
MARS RISES
SATURN RISES
OCCULTATION OF VENUS
AUG 26TH
IMMERSION - BELOW HORIZON
EMERSION - 8:58 A.M., E.S.T.
SETS
RISES
APRIL
MAY
JUNE
JULY
AUGUST


TOTAL ECLIPSE OF THE MOON
APRIL 12-13
8:32 E.S.T.
9:28
10:28
TOTALITY
11:54
0:54
OCCULTATION OF ANTARES
APRIL 16TH
1:50 E.S.T.
1:36 E.S.T.
2:50
OCCULTATION OF ANTARES
JUNE 9TH
9:38 E.S.T.
10:36
OCCULTATION OF VENUS
AUG. 28TH
IMMERSION - BELOW HORIZON
EMERSION - 6:58 A.M., E.S.T.
APRIL
MAY
JUNE
JULY
AUGUST
MARS SETS
SATURN TRANSIT
GREATEST ELONGATION
GAMMA VIRGINIS
PULCHERRIMA (ε BOOTIS)
MERCURY SETS
SOLSTICE
LONGEST DAY
LATEST SUNSET
EARTH FARTHEST FROM SUN
CLUSTER M13 IN HERCULES
VENUS SETS
JUPITER RISES
RING NEBULA IN LYRA M57
ALBIREO
JUPITER TRANSIT
GREATEST ELONGATION
JUPITER RISES
SATURN SETS
RISES
SETS
MERCURY RISES
VENUS RISES
JUPITER TRANSIT
EARLIEST SUNRISE
GREATEST ELONGATION
JUPITER SETS
MARS RISES
MERCURY RISES
SATURN RISES
XIII
XIV
XV
XVI
XVII
XVIII
XIX
XX
XXI
XXII
XXIII


TOTAL ECLIPSE OF THE MOON
OCT 6-7
8.05
9.20 TOTALITY 10.33
9.56
11.48
1.03 EST
8.50 EST
OCCULTATION OF VENUS
AUG 26TH
IMMERSION - BELOW HORIZON
EMERSION - 8.50 A.M. E.S.T
OCCULTATION OF SATURN
NOV 15TH
IMMERSION 8.31 A.M. E.S.T
EMERSION 9.42 A.M. E.S.T
GREATEST ELONGATION
GREATEST BRILLIANCY
EARLIEST SUNSET
SHORTEST DAY
SOLSTICE
EQUINOX
TWILIGHT
SETS
RISES
XXII
XXIII
XXIV
I
II
III
IV
V
VI
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
P.M.
A.M.
MDT.
STANDARD TIME
THE MARYLAND ACADEMY OF SCIENCES

	d h m
Total eclipse ends	6 21 33.2
Moon leaves umbra	6 22 48.1
Moon leaves penumbra	7 0 2.7

Almost exactly a month prior to each of these two total lunar eclipses there will be found on the Time Table a small circle and cross surmounted by the number 1895. These mark the central times of two similar total eclipses which occurred in that year. The number of days that have elapsed between each of the eclipses in 1895 and its mate in 1949 is just 19,756. So it is that for nearly every eclipse we see now a very similar one will occur in 19,756 days, or 54 years 32 days.

IV. A partial eclipse of the Sun, October 21, 1949, visible in eastern and central Australia, New Zealand, and the Antarctic regions.

The circumstances, in Central Standard Time, are as follows:

		Longitude	Latitude
	d h m	° ′	° ′
Eclipse begins	October 21 13 15.1	—154 24	—15 19
Greatest eclipse	21 15 12.5	—107 17	—61 41
Eclipse ends	21 17 9.5	+ 55 31	—66 11

The magnitude of greatest eclipse is 0.964 (Sun's diameter = 1.0).

Occultations

As seen at Washington, D. C., two occultations of Antares will take place during 1949, one on April 16 and the other on June 9. In addition, two daylight occultations occur, one of Venus on the morning of August 26 and one of Saturn on the morning of November 15. For the exact times of these occultations see the Time Table. For the times at other locations consult the *American Ephemeris*.

November 30, 1948.

The Planets in February, 1949

By RAYMOND H. WILSON, JR.

Note: The time employed is Central Standard Time unless otherwise indicated. The phenomena have been chosen and described for the North American continent, and especially for the United States. The basic data have been taken principally from the *American Ephemeris and Nautical Almanac*.

Sun. The sun will move northward from a position 17 degrees south of the equator at the beginning of the month to 8 degrees south at the end.

Moon. The phases of the moon will occur as follows:

First Quarter	February	6	2 A.M.
Full Moon		13	3 A.M.
Last Quarter		19	7 P.M.
New Moon		27	3 P.M.

The moon will be at perigee on February 14.

An occultation of σ Scorpii, close neighbor star to the west of Antares, will be generally visible on February 20 at about 4 A.M., C.S.T.

Evening and Morning Stars. Saturn will be visible most of the night, while Jupiter may be seen in the eastern dawn.

Mercury. On the last day of this month Mercury will be 27 degrees west of the sun. For ten days or so before that date it may be seen as early as an hour before sunrise.

Venus. Since it will be less than 15 degrees west of the sun at the beginning of the month, Venus will be disappearing from the morning sky.

Mars. Mars will be practically unobservable this month, owing to its proximity to the sun.

Jupiter. This planet will be fairly easy to observe in the morning sky toward the end of the month, when it will be rising before 5 A.M.

Saturn. Coming to opposition on the 21st, when it will be south at midnight, Saturn will be most favorably situated for observation. It will enhance the already conspicuous constellation Leo by wandering westward in an area some 5 degrees east of Regulus, which star it will outshine by a whole magnitude. The rings are not opened to their greatest width, but still may be observed effectively.

Uranus. Uranus will be moving slowly southwestward, about 3 degrees north of ζ Tauri.

Neptune. Neptune will be moving slowly northwestward at a position about one-third the way from γ Virginis to Spica.

Department of Mathematics, Temple University, Philadelphia, Pa.,
December 12, 1948.

Occultation Predictions for February, 1949

(Taken from the *Amerian Ephemeris*)

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

			IMMERSION				EMERSION			
Date 1949	Star	Mag.	Greenwich C.T.	*a*	*b*	Angle E from N	Greenwich C.T.	*a*	*b*	Angle E from N
			h m	m	m	°	h m	m	m	°
	OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′									
Feb. 4	88 Pisc	6.2	1 25.4	—0.4	+2.8	6	2 3.9	—0.5	—3.4	297
5	26 B.Arie	6.1	1 39.3	—0.9	+0.3	46	2 46.2	—0.5	—1.2	263
6	π Arie	5.4	3 39.9	—0.5	—0.7	69	4 42.9	0.0	—0.9	256
7	62 Taur	6.4	21 42.6	—2.0	+0.5	104	22 44.9	—0.8	+3.0	208
9	112 B.Auri	5.7	6 1.8	+0.1	—2.4	131	6 49.3	—0.5	—0.4	236
11	c Gemi	5.4	6 17.2	—0.5	—2.1	129	7 16.7	—0.7	—1.2	268
17	h Virg	5.4	8 57.0	—1.9	—0.5	103	10 4.7	—1.0	—1.7	331
20	σ Scor	3.1	10 39.3	—2.1	+0.3	87	11 56.2	—1.7	—1.1	313
22	62 B.Sgtr	6.0	10 48.6	—3.2	+3.4	30	11 20.3	—0.3	—1.9	344

Date 1949	Star	Mag.	IMMERSION Greenwich C.T.	*a*	*b*	Angle E from N	EMERSION Greenwich C.T.	*a*	*b*	Angle E from N
			h m	m	m	°	h m	m	m	°
	Occultations Visible in Longitude +91° 0′, Latitude +40° 0′									
Feb. 4	88 Pisc	6.2	1 10.3	—0.2	+3.7	357	1 52.6	—1.7	—3.4	293
5	26 B.Arie	6.1	1 16.2	—1.4	+1.0	44	2 33.3	—1.2	—0.7	255
6	π Arie	5.4	3 28.0	—1.2	—1.1	84	4 37.5	—0.7	—0.1	236
8	BD+24°674	6.3	6 21.9	—0.4	—1.6	99	7 22.1	—0.2	—0.8	253
11	*c* Gemi	5.4	6 19.7	..	..	177	6 48.0	—3.2	+2.5	222
17	*h* Virg	5.4	8 30.9	—1.0	—0.9	140	9 43.5	—1.7	—0.7	297
20	σ Scor	3.1	10 7.1	—1.1	+0.2	118	11 25.6	—1.8	0.0	290
21	43 Ophi	5.4	12 29.3	—2.1	+0.3	94	13 56.3	—2.1	—0.6	288
	Occultations Visible in Longitude +98° 0′, Latitude +31° 0′									
Feb. 4	88 Pisc	6.2	0 41.3	—1.1	+2.2	26	1 56.5	—1.7	—0.6	260
5	26 B.Arie	6.1	0 56.1	—2.2	+0.7	64	2 22.6	—1.5	+1.0	227
6	π Arie	5.4	3 37.6	—1.6	—4.3	126	4 19.2	—1.4	+3.8	191
8	BD+24°674	6.3	6 42.1	+0.5	—3.8	144	7 17.3	—1.4	+1.7	210
9	107 B.Auri	6.5	5 29.9	—4.4	+8.2	17	5 49.8	..	..	347
10	49 Auri	5.0	2 59.7	—2.2	+2.1	57	4 12.5	—2.2	—2.1	306
17	*h* Virg	5.4	8 42.5	+0.4	—3.0	183	9 28.3	—3.4	+1.0	258
20	σ Scor	3.1	10 5.5	—0.2	—1.2	155	11 7.2	—2.6	+1.1	260
21	43 Ophi	5.4	12 14.7	—1.8	—0.2	118	13 42.9	—2.6	0.0	271
	Occultations Visible in Longitude +120° 0′, Latitude +36° 0′									
Feb. 5	26 B.Arie	6.1	0 34.7	—0.2	+3.6	6	1 37.1	—3.1	—0.8	276
6	π Arie	5.4	2 36.7	—2.4	+0.1	80	4 0.0	—1.6	+1.4	221
6	45 Arie	5.9	7 16.8	—0.7	+0.9	34	8 3.4	+0.4	—2.1	296
6	ρ Arie	5.6	7 24.8	+0.1	—2.4	117	8 10.3	—0.4	+0.8	213
8	BD+24°674	6.3	6 18.5	..	..	153	6 44.7	..	..	193

Comet Notes

By G. VAN BIESBROECK

In the course of last month two more discoveries have lengthened the already long list of comets found this year.

Comet Bester V (1948 *m*) was found at Bloemfontein (South Africa) on November 24 as a 7.5 magnitude object in the position

Right Ascension $7^h\,37^m$, Declination —75°.

This is the fifth discovery to be credited to this very active observer in the last couple of years. The comet was described as being diffuse but nothing was added about the motion. Visibility was, of course, limited to the southern hemisphere. The comet must have been well followed there since W. P. Hirst (Cape Town) has already computed the following preliminary parabolic elements.

Perihelion passage	1948 Oct. 21.865 U.T.
Node to perihelion	273° 7′
Longitude of node	66 45
Inclination	87 45
Perihelion distance	1.2709 astr. units

The comet has already passed perihelion and is, therefore, on the decline. The orbit is so oriented that the comet will move rapidly northward. By the end of

December it will become visible at our latitude but the brightness will be already much reduced.

EPHEMERIS OF COMET 1948 *m*

		α	δ	
		h m	° ′	Mag.
1948 Dec.	27	2 45.4	—38 9	8.8
1949 Jan.	4	35.1	27 16	9.4
	12	30.5	18 0	9.9
	20	29.3	10 21	10.3
	28	30.5	— 4 6	10.9
Feb.	5	2 33.4	+ 1 4	11.4

This approximate ephemeris was computed from the above elements and the brightness deduced under the assumption of a variation inversely proportional to the sixth power of the distance from the sun. The magnitude might well be somewhat brighter.

COMET HONDA IV (1948 *n*) was found within two weeks of the previous one. This Japanese amateur, whose ability has been recognized by the occupying military authorities through the gift of a telescope, has already three earlier discoveries to his credit. The discovery was announced by Y. Hagihara, Director of the Tokyo Observatory, as follows:

1948 Dec. 5.83 U.T.
Right Ascension $13^h 50^m 2$, Declination —24° 20′
Diffuse object. Magnitude 9.

Only a very keen observer could have picked up such a faint object in such a difficult position. So far it can be seen only just before dawn at low altitude but the position is improving. So far we have no information about the future course. I recorded the object here as follows:

1948 Dec. 7.46930	$13^h 45^m 18^s.10$	—24° 37′ 40″.5	Mag. 9
Dec. 9.48087	13 42 41.36	—24 55 17.8	Mag. 10

It appeared as a centrally condensed coma some 2′ in diameter with a faintly indicated tail in position angle 290°.

L. E. Cunningham has announced the following preliminary parabolic orbit for COMET HONDA (1948 *n*).

Perihelion passage	1948 Nov. 20.404 U.T.
Node to perihelion	190° 1′
Longitude of node	234 18
Inclination	13 47
Perihelion distance	0.566 astr. units

He notes that the comet may have transited the sun on November 17. The ephemeris shows a southerly motion while the brightness is declining rapidly. This will remain a very difficult object for northern observers.

By now many observers in this country have seen the bright southern comet 1948 *l* whose discovery was reported last month. It remains, however, near the horizon in the second half of the night. By extra-focal comparisons using a binocular the writer estimated the overall magnitude as 4.9 on Dec. 7 and 5.5 on Dec. 9, so that by now it must be below naked-eye visibility. It appears now that the comet was seen by several people at the time of the total eclipse of the Sun on November 1, a week before the discovery was announced. It was recorded photographically from an altitude of 13,000 ft. by the R.A.F. flying over the British observing station at Nairobi (East Africa), the only landstrip on the

central line from which the eclipse was visible shortly after sunrise. The comet was at a distance of 105′ from the sun in position angle 230° which corresponds quite well with the location deduced from Cunningham's elements given last month. The flyers describe the comet as very conspicuous during totality. It is unfortunate that this information was not broadcast at once.

Little is to be added concerning the many previously mentioned faint comets that are in reach of larger telescopes. Comets 1948 *d* and 1948 *i* are still well located but are now fainter than 12th magnitude. The variable comet Schwassmann-Wachmann No. 1 (1925 II) has been recorded here on November 30 and December 7 as a large diffuse coma not brighter than 17th magnitude.

Williams Bay, Wisconsin, December 11, 1948.

METEORS AND METEORITES

Contributions of The Meteoritical Society

(Known Formerly as The Society for Research on Meteorites)

Edited by FREDERICK C. LEONARD
Department of Astronomy, University of California, Los Angeles 24

The Meteorites of Santa Rosa de Viterbo, Boyacá, Colombia (730,059)*

J. Emilio Ramírez, S.J.
Instituto Geofísico de los Andes Colombianos, Bogotá, Colombia
Communicated by Frederick C. Leonard

ABSTRACT

In April, 1810, a large mass of nickel and iron was found by Cecilia Corredor, on Tocavita Hill, not quite a mile from the main square of the town of Santa Rosa de Viterbo, Department of Boyacá, Republic of Colombia. It was recognized as a meteorite by two fellow travelers, Mariano de Rivero and Jean Baptiste Boussingault, in 1823, who found it in the local smithy, where it was doing duty as an anvil. The history of this and another inseparable meteorite, known as Rasgatá, is outlined from that time up to the present, and some suggestions are made to eliminate the confusion that has prevailed regarding these two meteorites. Finally, two large specimens of meteorites found recently near Santa Rosa de Viterbo are described.

Introduction.—In the year 1810, a large mass, composed mainly of iron and

*Read at the 11th Meeting of the Society, Albuquerque, New Mexico, 1948 September 7-8.

[In a private letter dated 1948 August 4, in answer to an inquiry from the undersigned, the author of this paper writes:

"The geographical coördinates of the place of find of the Santa Rosa meteorites are as follows: for the famous old Santa Rosa meteorites and the new 38.4-kg. piece, found in 1926: long. W. 72° 59′ 50″, lat. N. 5° 52′ 50″. The most recent piece, of weight 100.5 kg., was found in 1942 somewhat to the east of the forenamed place; the approximate coördinates are: long. W. 72° 50′ 00″ (?), lat. N. 5° 52′ 00″ (?)."

Hence, the definitive 7-digit coördinate number of the Santa Rosa meteorites appears to be 0730,059.—F.C.L.]

nickel, was found buried in the ground, on Tocavita Hill, near the village of Santa Rosa, Department of Boyacá, Republic of Colombia. As the years passed, this mass acquired the name of the Santa Rosa meteorite. It is well known to Colombians, altho historical details about it either have been forgotten or are entirely lacking, and it is famous the world over among meteorite collectors. Today, samples of meteoritic iron, labeled Santa Rosa, are found in all the great collections of meteorites. The Chicago Natural History Museum shows a sample weighing 99.2 kg.; the American Museum of Natural History in New York City has a piece of 6.5 kg.; the Smithsonian Institution in Washington, D. C., has another piece of 4.9 kg.; and samples of the Santa Rosa meteorite can be found in the British Museum (1.1 kg.), in Vienna (1¼ kg.), and in Tübingen (5.5 kg.), as well as in the Vatican Museum and in the Berlin and Leipzig collections. This and another sample of meteoritic iron, found at about the same time at Rasgatá, near Zipaquirá, were brought to the attention of the world by a great number of reports, monographs, and bibliographic items written about them in different languages; and scientists and travelers like Wilhelm Reiss,[23]† A. Stuebel of Germany, and Henry A. Ward of Rochester, New York, made special trips to the town of Santa Rosa to examine the meteorite and even to secure samples for their collections. The following short historical account of the Santa Rosa meteorites is based upon more than 25 papers and memoirs compiled mostly in photostatic form for this purpose. A list of them can be found in the bibliography at the end of the paper.

First Reports on the Santa Rosa Meteorite.—The first news about the Santa Rosa meteorite was given to the scientific world by Alexander von Humboldt,[1]† who addressed the French Academy of Sciences on Monday, October 20, 1823. This traveler and scientist summarized a letter from his friend, M. Jean Baptiste Boussingault, who wrote from Santa Fé de Bogotá, announcing the finding of several large masses of meteoritic iron, one of them weighing 750 kg. At the same time, the Spaniard, Mariano de Rivero, and the Frenchman, Boussingault,[2] published, in Bogotá, a joint memoir that was reprinted in Lima, by De Rivero, in 1828. According to this memoir, the two authors and fellow-travelers, while going from Pamplona in the north, to Bogotá in the south, arrived in 1823 at the village of Santa Rosa de Viterbo, which today lies on the highway linking the two capitals of Bogotá in Colombia and Caracas in Venezuela. At Santa Rosa, they were informed that an iron mine had been discovered on Tocavita Hill, not quite a mile to the east of the main square of the village, and that in April, 1810, a woman, named Cecilia Corredor, had found the great iron block that had been brought down to the village square by the combined efforts of the community. There it had remained until 1818, when it was removed to the local smithy to do duty as an anvil, a duty which it was still performing when the travelers passed thru the village. The two travelers recognized it at once as a meteorite. A thin, semi-lustrous coating, shading from brownish-black to rust-brown, incased the iron mass, and represented a somewhat altered, natural crust, filled with saucer-like depressions; furthermore, it was very hard and malleable, with a silvery luster, and had a specific gravity of 7.3. On going to the hill whence it came, Boussingault and De Rivero saw the excavation left by the extraction of the mass, which was found almost entirely underground. They found also other fragments of the same, pure, malleable iron, of a granular texture. Continuing

†These numbers refer to the references in the bibliography at the end of the paper.

their trip farther south, they saw two more meteorites, owned by a man named Jeronimo Torres, one weighing 41 kg., the other of about half that size, and both of them found in the region of Rasgatá, near the city of Zipaquirá, which lies 50 km. north of Bogotá. The chemical analysis made at Bogotá, of 1.28 gm. belonging to the main mass, yielded:

Iron	91.41%
Nickel	8.59
Total	100.00%

One of the Rasgatá samples yielded:

Iron	90.76%
Nickel	7.87
Total	98.63%

In 1824, this famous memoir was translated in full into French and in part into German and published in the leading scientific journals, *Annales de Chimie et de Physique*[2] and *Annalen der Physik und Chemie*.[3]

Specimens in European Collections.—Samples of the Santa Rosa and Rasgatá meteorites began to pour into Europe shortly afterwards, and pieces of them were presented to the main collections. Other pieces were divided and sold, or given away as gifts or exchanges. This procedure was typical of what happened at the time. The Rasgatá meteorite was brought into Europe in the form of a 7.43-kg. piece, which was sent by De Rivero to a mineral collector named Heuland, in London. It was soon sold to Heath of Madras, India, for his splendid mineral collection. In 1837, it was bought for a large sum of money by Potschke in Vienna. It was then divided, and a fragment of 1.3 kg. was turned over to Professor Partsch for the collection of the Vienna Royal Imperial Museum. As a result of all this dividing, selling, and giving away, the utmost confusion arose about the Colombian meteorites, augmented perhaps by their similarity of structure. In the opinion of some museum curators, the Santa Rosa and Rasgatá meteoritic irons were scarcely to be told apart. Tocavita was made identical with Rasgatá in many instances; and, to make matters worse, the labels of the two meteorites seem to have been interchanged by the museum curators!

In an effort to find out the real difference between the two meteorites, and especially to determine their nickel content, Professor Wöhler,[4] of the University of Göttingen, in 1852, undertook a careful chemical analysis of a specimen from Rasgatá, at the request of Professor Partsch. The result of this often-quoted analysis, made on a fragment of 3.977 kg., was the following:

Iron	92.35%
Nickel	6.71
Cobalt	0.25
Phosphorus-Nickel-Iron	0.37
Phosphorus	0.35
Olivine and other minerals	0.08
Copper, zinc, and sulfur	Traces
Total	100.11%

Professor Partsch of Vienna was the first person who tried to obtain Widmanstätten figures on the polished surfaces of these meteorites, by etching with dilute nitric acid. The trial was made shortly after Dr. A. von Widmanstätten, the discoverer of this method for testing nickel-iron meteorites, died in Vienna in 1849. According to Partsch,[5] the Rasgatá samples showed these cuneiform-

like figures in an obscure way. In 1859, Professor Reichenbach,[10] of the University of Tübingen, grouped and classified the University meteorites; and the Santa Rosa and Rasgatá samples were considered "as two different irons, the one from Rasgatá being homogeneous in nature, and the other, one on which the Widmanstätten figures could be shown."

The Berlin Dispute.—The meteorite collection of Berlin enjoyed the (peaceful) possession of two round meteorites labeled Santa Rosa, Colombia. They were obtained in 1823 in Paris by Professor Rose from the hands of Von Humboldt, who had received them from Boussingault; furthermore, there was another piece, labeled Rasgatá, Colombia, obtained from Professor Partsch, from the Royal Imperial Museum in Vienna. Professor Rose[11] described these three meteorites as being very similar to one another, of great hardness, and of fine grain; but it happened that a new, smaller specimen from the main mass of the Santa Rosa meteorite was brought from Bogotá, Colombia, and presented to the Berlin collection by H. Karsten. This physician and traveler, who had never been at Santa Rosa, received the sample from a trustworthy friend who brought it for him from that town. This specimen caused an uproar among the curators of the Berlin collection. It was so different from the specimen labeled Santa Rosa that Professor Rose called for a careful revision of the specimens and for a better analysis. Since Karsten had no doubt of the genuineness of his piece, he indicated that the two places of origin, Santa Rosa and Rasgatá, were confused. He suggested, furthermore, that Boussingault should be consulted on the point; and, in the meantime, he put the two specimens together under the same general description. Von Lasaulx[12] then saw an opportunity for removing the doubt, and wrote a monograph on the Santa Rosa meteorite in 1884. He joyfully announced that there had been sent to him a small fragment, cut off from the large meteorite from the main square of Santa Rosa, by his good friend, Dr. A. Stuebel, and that he had undertaken a chemical and physical examination of this piece, in the hope of clearing up the uncertainties left by Professor Rose of Berlin. He compared the chemical analysis of his genuine Santa Rosa sample with Boussingault's analysis of his Santa Rosa sample and Professor Wöhler's analysis of the Rasgatá piece. His final conclusion was that the samples found in Santa Rosa or nearby places show the same characteristics, and therefore belong to the same fall or origin, but that the sample brought by Karsten should be considered as spurious.

Among the scientists who occupied themselves with the study of the Santa Rosa and Rasgatá meteorites should be mentioned: Sjöström, Rumler, Arago,[8] Seeback, Shepard, Meunier,[13] and Brezina.[17] The last-named investigator pointed out the fact that one of the specimens in the Tübingen collection, entitled Santa Rosa, belonged really to another town called Santa Rosa, in Toluca, Mexico!

The Investigations of Cohen.—Perhaps the most thoroly made study, as well as the most noteworthy step toward clearing away the confusion that for many years hopelessly mixed up the different Colombian meteorites, was undertaken by E. Cohen.[18] In 1895, he revised and again analyzed each of the 9 specimens of Colombian meteorites that were to be found in the German and Austrian collections, and he distinguished 3 group-localities:

(I) Santa Rosa: Represented by the great mass in the village square and by fragments brought to Europe by Dr. Reiss and Dr. Stuebel. Brecciated octahedrite of the Zacatecas group. Coarse grain. Specific gravity, 7.689, at 16° C.

(II) Tocavita: Represented by the fragments mentioned by De Rivero and

Boussingault as having been picked up on Tocavita Hill and by a few pieces in meteorite collections, notably that of Reichenbach. Finer octahedrite. Specific gravity, 7.85, at 14°8 C.

(III) Rasgatá: Represented by the Rasgatá masses, spoken of by De Rivero and Boussingault, and by most of the material known variously as Rasgatá, Santa Rosa, and Tocavita, in meteorite collections. Nickel-poor ataxite, Nedagola group. Specific gravity, 7.654, at 16° C.

This differentiation, while the best that could be made in the circumstances, formulated a distinction that does not really exist between Santa Rosa and Tocavita, for the Santa Rosa main mass was found really on Tocavita Hill; furthermore, the differentiation is hypothetical, and, according to some, contains an element of uncertainty introduced by the inexactness in the history of the material available for examination. Cohen, for a final and easy comparison among the three meteorite groups, gave the following table:

	(I) Santa Rosa	(II) Tocavita	(III) Rasgatá
Fe	92.30%	89.81%	92.81%
Ni	6.52	9.77	6.70
Co	0.78	0.57	0.64
Cu	0.02	0.02	0.01
Cr	Trace	Trace	Trace
C	0.18	0.03	0.19
P	0.36	0.22	0.28
S	0.04	0.06	0.08
Total	100.20%	100.48%	100.71%

But the difficulty was not entirely solved. Ward[21] mentions the fact that Wülfing,[20] in 1897, while preparing his great work on meteorites and despairing of the success of any attempt to differentiate among the Colombian meteorites, grouped them all under the general heading of Rasgatá. He found recorded in the great collections of the world a grand total of 9.443 kg. of Santa Rosa and Rasgatá, taken together; some 1100 gm. bore the former name; the remainder, the name of Rasgatá. No sharp line of distinction was ever drawn between the two. When they were spoken of together, it was with an expression of their similarity. Indeed, in some few instances, an indifferent interchange of the two names seems to have taken place.

Ward's Visit and Comments.—In the hope of contributing to the problem of Colombian meteorites and securing the large meteorite from the market place of Santa Rosa for his collection, Henry A. Ward set out from Rochester, New York, on a trip to Colombia in the early spring of 1906. Let us quote some paragraphs of the unfinished paper he began shortly before his death on July 4, 1906. In this paper it can be seen that he was only partially successful in his two main purposes.

"When I reached the village, I found the object of my long journey crowning a fluted column beside the fountain, whence the entire community derives its water supply. An inscription stated that it had been set up in 1874. . . The early estimates as to the size of the great mass were exaggerated, as its weight is only 612.5 kg. Its three dimensions were 77 cm., 49 cm., and 46 cm. In view of the considerable distribution claimed for the Santa Rosa iron among the various museums, it is an interesting fact that the most careful scrutiny of its exterior, before cutting, failed to reveal a single place whence even the smallest piece had been removed. . . In due time, full possession of the historic siderite was secured, and it was started on its way to Bogotá. There, however, the con-

tract with the Santa Rosa municipality was nullified, and the meteorite was seized for the National Museum. After protracted argument, a compromise was arranged, by which a piece weighing 150 kg. was cut from the small end (battered by the smith's sledge) of the meteorite, and turned over to me. In addition to this, a piece of one of the Rasgatá masses, weighing 5½ kg., was secured from the Bogotá National Museum, where the main part of this meteorite resides."

Ward brought his samples to Rochester, and proceeded to slice them. He had great difficulty in slicing the Santa Rosa fragment of 150 kg.: "Great difficulty was experienced in slicing the iron. A gang of 8 saws, fed with emery, was kept turning for 197 hours to obtain 7 pieces, ranging from 450 to 600 square cm. in size. When it was finally laid open, the first thing about the sections to attract attention was what appeared in section to be almost, if not quite, perfectly spherical troilite nodules from 3 to 6 mm. in diameter. It was not until a closer scrutiny, and after a comparison of the concretions in different slices, that they were found to be cigar-shaped, rather than spherical. The lay of these is, as nearly as may be determined, mutually parallel."

In his conclusion he states that the structure of the item has been described by Cohen and Brezina so as to make further comment unnecessary.

Posada's and Codazzi's Accounts.—Finally, two more writers have shown their interest in the Colombian meteorites: Eduardo Posada[25] and Dr. Ricardo Lieras Codazzi.[24] The former wrote in his *Apostillas* a short historical account with some inaccuracies as to the person who secured the big slice from the main mass of the Santa Rosa meteorite in 1906. The latter studied the meteoritic samples of the National Museum at Bogotá, and gave descriptions of them in his *Notas Mineralógicas y Petrográficas,* published in 1925.

Conclusion.—After a careful and thoughtful reading of the 25 reports on the Colombian meteorites, and after several days' excursions in the localities of both Santa Rosa and Rasgatá, it is my firm conviction that there has not been reasonable ground for doubting the genuineness of the labels of the Santa Rosa and Rasgatá meteorites in the European collections. The keepers and curators of the mineral collections were so meticulous about taking note of the origin of the specimens, and in describing them, and the lists are so full of details, that it is possible to trace back almost every sample to the original source; furthermore, the persons who intervened or presented the samples were in most cases well-known scientific writers, such as Boussingault, Von Humboldt, Partsch, Reiss, and Stuebel. In Colombia, all the meteorites found for many kilometers around the town of Santa Rosa are known as Santa Rosa meteorites. The Rasgatá meteorites have been rather scarce, and there has been no confusion about them; moreover, it is to be expected that pieces of meteorites, originating from small and large masses found scattered over a wide land surface, should possess slight differences of structure and small variations in their chemical composition. The largest percentages of Fe and Ni found in the many analyses were 93.93% and 9.77%, respectively. The main source of error has been, rather, in a lack of *geographical* knowledge! Even today, *Bulletin No. 94 of the U. S. National Museum,* 1916,[22] carries (on p. 131) the following erroneous label for a piece of 645 gm., obtained by H. A. Ward from the museum at Bogotá in 1906: "Rasgatá (Tocavita), Province of Boyacá, Colombia, South America." Rasgatá is an almost forgotten name of a *region,* not a town, in the Departamento de Cundinamarca, near the well-known city of Zipaquirá, which is 50 km. north of Bogotá, the capital city of Colombia! Santa Rosa, on the contrary, is an old town in the

Departamento de Boyacá, 239 km. north of Bogotá! The name of Tocavita is without significance in Santa Rosa today. My attempts to obtain any information from the old inhabitants of Santa Rosa, of the geographical position of Tocavita, failed altogether; however, Boussingault, who visited Tocavita Hill, states that it is a quarter of a league east of Santa Rosa; so it must be a little more than a kilometer from the main square of Santa Rosa. This somewhat elevated terrane is today the property of the Jesuit Novitiate in Colombia, and, on this property, and in the surrounding territory since 1810, until the present day, several meteorites, both large and small, have been found buried in the ground. These meteorites are to be found mostly in the private collections of Colombia.

The New Discoveries.—The two largest pieces found in recent years are, first, a meteorite (Fig. 1) of irregular shape, cavernous, very hard, malleable,

FIG. 1

A nickl-iron meteorite weighing 38.4 kg., found in 1926, 1 km. east of the main square of Santa Rosa de Viterbo, Boyacá, Colombia. The slice cut from it, shown at the bottom of the picture, shows a spot painted white, where a cigar-shaped incrustation of troilite was removed. This meteorite is shown in the seismic vault of the Instituto Geofísico de los Andes Colombianos, Bogotá, Colombia.

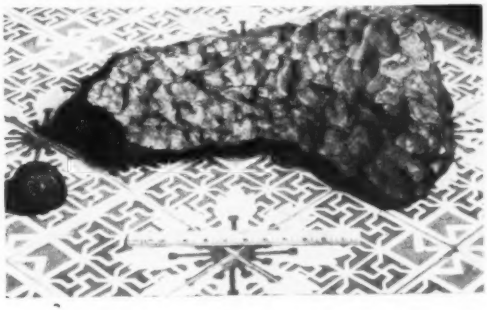


FIG. 2

A new meteorite of nickel and iron, found in 1942, about 15 km. east of the main square of Santa Rosa de Viterbo, in the municipality of Floresta, Boyacá, Colombia. It weighs 100.5 kg. and belongs to the mineral collection of the Instituto Geofísico de los Andes Colombianos, Bogotá.

with a silver-like luster, weighing 38.4 kg. This was found in 1926, about 1 km. east of the main square of Santa Rosa, within the Jesuit property, and 50 cm. below the surface of the ground. The slicing of a piece, for the examination of its structure, required 14 hours of work with an electric-power saw. Parallel, cigar-shaped incrustations of troilite were found when the meteorite was opened. This meteoritic iron and its slice are kept in the seismological vault of Bogotá, and are shown to visitors inquiring about the nucleus of the Earth's interior, which is supposed to be composed mainly of nickel and iron.

The second meteorite (Fig. 2) weighs 100.5 kg., and is very similar in appearance to the other one. It was found in 1942, about 10 km. east of the main square of Santa Rosa, in the municipality of Floresta. This was acquired shortly afterwards by the Rev. Cándido Gaviña, S.J., Rector of the Jesuit Novitiate at Santa Rosa, and, in 1945, it was turned over to me; it is exhibited among the Colombian minerals of the Instituto's collections. Both of these meteorites belong to the Instituto Geofísico de los Andes Colombianos, at Bogotá, Colombia.

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VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

A New R Coronae Borealis-type Variable: In a Harvard Reprint from the *Astronomical Journal,* Professor Chang Yuin of Canton, China, who spent a year at Harvard, reports on a new variable star of the R Coronae Borealis type. From the appearance of its spectrum, Dr. Bidelman of the Yerkes Observatory had stated that the star had the same characteristics as those of the hot carbon star, R Coronae Borealis, and that it might show similar variability. Dr. Chang examined some 1170 Harvard plates taken from 1898 to 1947, and found only one observed minimum over the 50-year interval. This does not mean that other minima did not occur, for there were intervals of 100 days or more when, because of seasonal gaps, no observations were obtained. The star at normal maximum hovered around photographic magnitude 8.6 to 8.7, and at the one observed minimum, decreased to magnitude 10.4. The minimum occurred between November 17, 1939, and February 20, 1940, with the faintest magnitude on January 2, 1940, and with a very symmetrical light curve, not dissimilar to that of an eclipsing star. In fact, were it not for its spectral characteristics, one might be led to the conclusion, from the plot of the observations, that the star is an eclipsing variable of very long period. Although the observed range is only about 1.7 magnitudes, it is not impossible that the star may have a greater range at other minima. R Coronae Borealis itself has varying depths of minima on occasion, with a range of more than seven magnitudes.

R Coronae Borealis: Late in November, the variable star R Coronae Borealis, which has been at maximum brightness, magnitude 6.0, since April, 1947, began to decrease in light but faded only to magnitude 7.0, where it now appears to be stationary. This feature is not unprecedented for this star. In the past, a slight decrease in light has frequently been the precursor of a deep minimum within a short time thereafter. Although the field of R Coronae Borealis is now unfavorably placed for observation, the star can be observed just before dawn.

Reverend Tilton C. H. Bouton: On October 24 occurred the death of Reverend Tilton C. H. Bouton of St. Petersburg, Florida, who, had he lived until November 2, would have attained the venerable age of 92.

Mr. Bouton, until he reached his 90th birthday, had been an assiduous observer of variable stars from the inception of the AAVSO in 1911, having been one of the first to answer Mr. Olcott's appeal for observers. He began his work while in Hudson, New Hampshire, using a 6-inch refractor, and later moved to Florida where he installed a 7-inch. Although he gave up observing the variables in 1946, he continued to entertain visitors at his observatory almost to the last.

In 1936 he received the second Merit Award of the AAVSO, and in 1946 was elected to Honorary Membership in the Association. His zeal and devotion to the Association for nearly forty years have been an inspiration to his fellow members.

Predicted Dates of Maximum of Long-Period Variables, 1949: Listed herewith are predicted dates of maximum for long-period variables which, on the average, attain a maximum magnitude of 8.0 or brighter. These values are taken from a recent AAVSO Bulletin, which contains dates of maximum and minimum for nearly 400 such variables. Copies may be obtained by addressing the AAVSO Recorder. These predictions are made possible by the continued activity of the AAVSO observers located in both northern and southern hemispheres. In the successive columns are given the designation and name of the variable, the month and day in 1949 of the predicted maximum, and in the last column, the *mean* maximum magnitude. Actual brightness at maximum may differ by a magnitude or more in some instances.

Design.	Name	Date Max. m	d	Mean Max. Magn.
0010*32*	S Scl	12	19	6.8
001755	T Cas	2	27	7.8
001838	R And	1	23	7.0
021143a	W And	10	17	7.5
0214*03*	o Cet	8	23	3.7
0228*13*	U Cet	3	4	7.5
"	" "	10	25	
023133	R Tri	1	20	6.3
"	" "	10	13	
0250*50*	R Hor	1	13	6.0
0432*63*	R Ret	6	6	7.7
0455*14*	R Lep	3	22	6.7
050953	R Aur	6	28	7.8
0515*33*	T Col	7	21	7.6
054920	U Ori	2	12	6.6
055686	R Oct	6	1	7.9
0617*02*	V Mon	1	12	7.1
"	" "	12	12	

Design.	Name	Date Max. m	d	Mean Max. Magn.
0652*08*	X Mon	2	8	7.6
"	" "	7	13	
"	" "	12	15	
065355	R Lyn	4	29	7.9
070122a	R Gem	3	10	7.1
072708	S CMi	10	25	7.5
081112	R Cnc	4	16	6.8
0824*05*	RT Hya	7	26	7.6
084803	S Hya	3	28	7.9
"	" "	12	11	
0850*08*	T Hya	1	2	7.7
"	" "	10	18	
0929*62*	R Car	5	11	4.6
093934	R LMi	10	24	7.2
094211	R Leo	2	19	5.9
"	" "	12	29	
1006*61*	S Car	3	20	5.7
"	" "	8	16	

Design.	Name	Date Max. m d	Mean Max. Magn.
103769	R UMa	1 10	7.6
"	" "	11 7	
114441	X Cen	9 18	7.8
121418	R Crv	2 3	7.6
"	" "	12 17	
122001	SS Vir	11 5	6.9
123160	T UMa	7 11	7.9
123307	R Vir	4 2	6.9
"	" "	8 25	
123961	S UMa	8 8	7.9
132422	R Hya	4 21	4.6
132706	S Vir	5 6	7.1
133633	T Cen	1 22	6.1
"	" "	4 23	
"	" "	7 23	
"	" "	10 22	
134440a	R CVn	6 3	7.7
140959	R Cen	3 14	5.9
142539a	V Boo	2 22	7.9
"	" "	11 9	
143227	R Boo	7 20	7.3
151731	S CrB	8 2	7.5
151822	RS Lib	2 12	7.7
"	" "	9 18	
152849	R Nor	10 7	7.2
153654	T Nor	3 11	7.4
"	" "	11 8	
154615	R Ser	7 1	6.8
154639	V CrB	5 7	7.4
162112	V Oph	9 26	7.5
162119	U Her	10 3	7.6
163266	R Dra	3 14	7.6
"	" "	11 14	
164715	S Her	6 9	7.6
164844	RS Sco	9 8	6.8
165030a	RR Sco	8 1	6.0
170215	R Oph	6 14	7.6
182133	RV Sgr	9 21	7.8
183308	X Oph	8 10	6.9
190108	R Aql	3 16	6.3
191019	R Sgr	8 15	7.2
193449	R Cyg	4 18	7.3
194048	RT Cyg	3 24	7.4
"	" "	9 30	
194632	Chi Cyg	9 2	5.3
194659	S Pav	8 21	7.3
194929	RR Sgr	6 16	6.6
195142	RU Sgr	3 24	7.2
"	" "	11 19	
200938	RS Cyg	8 21	7.4
201139	RT Sgr	10 17	7.9
201647	U Cyg	1 16	7.6
204405	T Aqr	5 15	7.9
"	" "	12 3	
210868	T Cep	5 3	5.8
221948	S Gru	3 2	7.8
230110	R Peg	2 9	7.9
230759	V Cas	5 26	7.9
233815	R Aqr	7 30	7.3
235150	R Phe	4 9	7.8

Observations received during November: A total of 4101 observations was received in November from 64 observers, as follows:

Observer	No. Var.	No. Ests.	Observer	No. Var.	No. Ests.
Ahnert	51	504	Hamilton	6	19
Ancarani	25	32	Hardi	5	20
Bogard	46	123	Hartmann	166	174
Buckstaff	13	32	Herring	13	21
Bufkin	4	20	Hiett	12	14
Cain	8	9	Holloway	2	2
Chassapis	96	180	Kirchhoff	37	96
Cilley	20	50	de Koch	104	361
Cragg	28	29	Kulin	4	11
Daley	17	33	Luft	8	63
Darling	7	18	Miller	16	25
Dillon	5	6	Oravec	48	169
Edelenyi	4	10	Paletsakis	8	131
Estelberg	1	1	Parker	30	30
Escalante	55	67	Parks	30	39
Estremadoyro, G. A.	3	3	Pearcy	97	102
Estremadoyro, V. P.	5	6	Peltier	54	109
Farkas	3	6	Penhallow	18	32
Fernald	317	743	Pierson	33	43
Focas	8	10	Plakidis	5	23
Ford	4	4	Rakosi	5	26
Garneau	14	15	Renner	85	90
Gingerich	7	14	Rich	6	8
Greenley	46	124	Rosebrugh	24	110

Observer	No. Var.	No. Ests.	Observer	No. Var.	No. Ests.
Ruiz	4	4	Wade	2	2
Rusho	6	7	Waters	3	4
Seagroves	9	9	Webb	26	28
Svolopoulos	50	83	Welker	23	47
Taboada	57	58	Wells	5	5
Tarbell	9	25	Wilmot	3	3
Tifft	23	26	Zadunaisky	3	5
Upjohn	20	20	—		—
Venter	10	18	64	totals	4101

December 15, 1948.

General Notes

William M. Kearons, well known in astronomical circles for his successful work in photographing sunspots, died suddenly at his summer home in Dorchester, N. H., on August 13, 1948. One of his photographs was published in POPULAR ASTRONOMY, **45**, 254. As a rector in the Episcopal Church, Mr. Kearons served in parishes in various parts of the United States. In 1944 he retired from active service in Fall River, Massachusetts.

The Rittenhouse Astronomical Society, of Philadelphia, held its monthly meeting on December 10, 1948, in Randal Morgan Physics Laboratory, University of Pennsylvania. The speaker was Henry P. Adams, of the Philadelphia Weather Bureau. His topic was "The Weather Forecast—How it is made. Why it is missed."

Sproul Observatory

An attractive well-illustrated pamphlet of twenty pages has recently been issued under the above heading. It is descriptive of the history of the founding, the work done in the past, and the work being done at present at this institution. It is serving both as a research center and as a teaching institution in Swarthmore College. A marked feature of this observatory is its collection of more than 25,000 photographic plates made with the 24-inch reflector since its was mounted in 1911.

Warner and Swasey Observatory

The Warner and Swasey Observatory, as in former years, has arranged an interesting series of topics for consideration on the schedule of public nights at the Observatory. Two dates are indicated in each case, presumably in an attempt to avoid interference by clouds as far as possible. Following is the complete list of events for the current season.

October 14 and 15, The 200-inch on Palomar Mountain; November 11 and 12, The Sun and Its Motions; December 2 and 3, The Winter Sky; January 6 and 7, Suns Which Vary in Brightness; March 10 and 11, Exploring the Universe; April 7 and 8, Giant Planets, Jupiter and Saturn; May 5 and 6, Star Families; June 2 and 3, The Summer Sky.

The Observatory will be open at 7:45 P.M. Lecture will be at 8:00 P.M.

Demise of a Computing Machine

Some months ago I was informed by the Directors of the Cambridge (England) Observatories that they proposed to discard, as junk, a small Thomas de Colmar arithmometer. Knowing that I had played with this machine thirty years ago, when it was already more than half a century old, and obsolete, they inquired if I knew of any museum that would care to accept it. As British museums are already fully equipped and refuse offers, I suggested the new Harvard Computation Laboratory. On inquiry I found that Professor H. H. Aiken would be glad to house this miniature with his 8-ton giants. So the machine was brought from Cambridge and packed for transport to the other Cambridge, in U.S.A.

Then the fun began. Forms had to be filled in, on which the machine was naturally stated to have no commercial value. These went backward and forward several times, through our bankers, to the Bank of England, whose final answer was that they "were unable to authorise the export of this machine."

The law that controls the export of valuables is an excellent one, designed to frustrate the secret acquisition of assets abroad by means that would be detrimental to our country. But a less imaginative administration of the law by the civil servants of a now nationalised but once highly-respected institution would be difficult to conceive. The machine must now be buried in the coffin of its packing case—for its value as scrap metal is less than the cost of the labour of undoing its wooden box, which, unfortunately, must still be paid for.

1948 October 20. L.J.C.

Amateur Astronomy in Germany

The public astronomical observatory in Munich is the center of considerable activity in astronomy by amateurs. An energetic society has headquarters at the observatory under the leadership of Heinz Zoch. No less than four pamphlets were issued last year under his direction, all for the interest and benefit of the members of the society.

1. The first of these to be mentioned is entitled "Ich zeige Dir die Sternbilder," or, translated freely, "I will show you the stars." This pamphlet, with its 60 star charts does just that. A key to the charts enables one easily to select the proper chart for the time, and also to discover the time of sunrise and sunset, and the beginning and ending of twilight. A helpful feature is the fact that the course of the ecliptic is shown on the several charts. The pamphet is concluded with a list of and positions of the constellations and the names of 39 of the brightest stars with the constellations in which they are found.

2. The second is slightly larger and bears the title, "Das Weltall in Zahlen," or "The World in Numbers." The table of contents lists 21 items which are included. These are for the most part composed of statistical data related to a great variety of astronomical questions. This pamphlet serves a very useful purpose in assembling so much information in such little space.

3. The Munich Astronomical Booklet for 1948. This is a small-sized almanac. As indicated, most of its material pertains to the current year. As such, it duplicates some of the data in the other pamphlets. It consists of 16 pages and a cover.

4. The Course of the Planets in 1948. This pamphlet, like number 1, is of pocket size. Its principal purpose is to trace the five naked-eye planets among

the stars during the year. Various charts and devices are used to accomplish this.

With this material at hand, anyone who can read German is well equipped to become familiar with the starry sky and with the elements of classical astronomy.

Early Aeronautics

The airplane having become such an important element in present-day living, it is of interest to turn back in thought to the beginning of this phenomenon. We do so here by quoting from an exhibit recently held at the Library of Congress in commemoration of the centenary of the American Association for the Advancement of Science. It is taken from a page of the diary of Orville Wright, the date of it being December 17, 1903, the day of the first flight.

> "When we got up a wind of between 20 and 25 miles was blowing from the north. We got the machine out early and put out the signal for the man at the station. Before we were quite ready, John T. Daniels, W. S. Dough, A. D. Etheridge, W. C. Brinkley of Manteo, and Johnny Moore, of Nags Head arrived. After running the engine and propellers a few minutes to get them in working order, I got the machine at 10:35 for the first trial. The wind according to our annemometers at this time was blowing a little over 20 miles (corrected) 27 miles according to the Government annemometer at Kitty Hawk. On stopping the rope the machine started off increasing speed to probably 7 or 8 miles. The machine lifted from the track just as it was entering the fourth mile. Mr. Daniels took a picture just as it left the tracks. I found the control of the front rudder quite difficult on account of its being balanced too near the center and thus had a tendency to turn itself when started so that the rudder was turned too far on one side and then too. . ."

The Green (?) Flash (?)

The Green Flash, a much discussed but seldom observed phenomenon, is here given a very clear description by an acknowledged authority. We are indebted to The Journal of the British Astronomical Association, Volume 58, No. 7, for this item. Our thanks are hereby expressed for it. EDITOR.

All my life I have looked, as opportunity offered, for the so-called green flash; I had conspicuously failed to catch it. Tonight, over the smooth water of the Red Sea, I have seen it.

I now know the main reason for my previous failures; my conception of what I was looking for was at fault. I had expected something *green*—and pictured emerald green; I had expected a *flash, i.e.,* something momentary like lightning, whose duration was no more than that of the well-known persistence of vision; and I had expected something extending perhaps 20′ or 30′ above and around the sunset point. It was none of these things.

The sun set in a rosy sky, so that the light-sensitive cells of my eyes were saturated with red light—a prerequisite to the observed complementary colour reaction. Just after the last trace of Sun had disappeared—say within a second—a small irregularly defined patch of *bluish green* light perhaps 6′ long (one-

fifth of the Sun's diameter) and a minute or so high developed (that is the best word I can find for a non-instantaneous phenomenon) on the horizon around the sunset point, and, perhaps in another second, collapsed (this word does not suggest instantaneous extinction).

I was so taken by surprise at my success in seeing what had previously eluded me, that it was a second or two before I realized that *this* was the green flash; hence my description of dimensions and times may be somewhat imperfect. The biggest shock came from the fact that the colour was not emerald green, but could more fairly be described as *bluish* green; secondly the smallness of the whole effect was contrary to my expectation. At the next opportunity, I shall know better what to look for.

The colour, dimensions, and duration, being purely physiological, may easily vary with individuals, with the extent of the previous fatiguing of the red-sensitive cells, and with the sharpness of the actual sunset. This latter in turn could depend on the smoothness of the horizon, since a swell could allow lingering shafts of light to reach the eyes just as the mountainous edge of the Moon gives rise to the "Baily's Beads" effect at a total solar eclipse.

L. J. COMRIE.

R.M.S. Stratheden, Red Sea. 1948 June 25.

Cleveland Astronomical Society Meetings

Ninety-two persons attended the meeting of the Cleveland Astronomical Society on October 8, 1948, at the Warner and Swasey Observatory of the Case Institute of Technology. The size of the audience on a rainy evening was a tribute to the drawing power of the speaker, Dr. Nicholas T. Bobrovnikoff, Director of the Perkins Observatory of Ohio Wesleyan University and Ohio State University. The topic of his lecture is a specialty of his "Comets." The speaker partially attributed his interest in this subject to the fact that early in 1925, he obtained an unusual bright-line spectrum of a comet with the Bruce telescope at Yerkes Observatory. His interest continued despite the fact that it was soon deduced that the circles had been set improperly and the "comet" was really Gamma Cassiopeiae.

In the introductory remarks, a comet was defined as a "swarm of small particles surrounded by a gaseous atmosphere." In support, it was mentioned that comets easily break up and that the components have been seen, that the particles are invisible when the comet is projected against the sun, that stars are undimmed when a comet passes over them, and that some fifteen meteor showers are definitely associated with comets. Comets are very tenuous, particularly the tails; it was recalled that remedies against cometary infection were sold at the time the earth passed through the tail of Halley's Comet, despite its very low density. The number of comets which have been actually observed is about 1400, but the total number in the solar system was estimated as many millions. The factors which make comet-seeking particularly suitable for the amateur were mentioned, and as a pastime it was compared with fishing, in that patience is an important requirement. Barnard's phenomenal success was described, including his famous "comet house" built by prize money won by his discoveries. It was also mentioned that the records show a marked decline in Barnard's comet discoveries after 1893—about the time he became a professional astronomer.

In a section devoted to the history of comets, it was brought out that superstition has aided astronomy in that it has resulted in very good records being kept of them—along with eclipses and bright novae and meteors. Halley's was

mentioned as the first *bona fide* comet, observed as early as 467 B.C., and having now completed thirty-one revolutions. Tycho Brahe was credited with making the first scientific approach to the problem of the distance to a comet by attempting to measure its parallax. Previously comets had been attributed to the atmosphere of the earth as they were thought to be "irregular and imperfect" and hence could not be in the sky—the "quintessence" of perfection. The rather large number of bright comets which appeared in the last century was noted, as well as the relative deficiency of spectacular comets in the present century.

The admirable contributions of Newton, Bessel, and Bredichin to the development of the mechanical theory of the formation of comets were described. The tails are apparently formed by one of two types of ejection. One of these is known as the syndaname, and may be thought of as being a single ejection force operating over an appreciable interval of time, commonly resulting in a narrow tail. The other is called the synchrone, and, as its name implies, the tail is formed by a single explosion and is frequently fan-shaped.

In a survey of the spectrographic results, the molecules and atoms which have been observed in comets were listed. The lecture was concluded with some brief comments concerning the mechanism governing the brightness of comets. The many questions which arose in the discussion period gave evidence of the interest aroused in the audience by this scholarly presentation.

The speaker at the meeting of the Cleveland Astronomical Society on November 19, 1948, was its founder and president, Dr. J. J. Nassau, who spoke to 128 members and guests on the topic, "The 200-inch Telescope."

The lecture was based on the lives and works of three famous astronomers, Hale, Galileo, and Newton. As the speaker had visited California, Italy, and England (among other places) during the preceding summer, he was able to make many personal remarks concerning the geographical references which enlivened the talk considerably.

The "flashback" method was used in the speech, which opened with a discussion of the 200-inch telescope, including its historical background in America and a biographical sketch of Hale. Then the invention of the telescope was neatly interjected. This included the story of Galileo's developments and his early discoveries, as well as his tribulations with the church. Newton's investigation of the reflecting telescope was then discussed as another milestone in the progress of astronomy, again with interesting biographical comments. Many colored slides, taken during the summer travels of the speaker, also enhanced the presentation, which, in the opinion of this reviewer, was very well done (despite the fact that the speaker was slightly indisposed), and well received by the large crowd.

After the discussion period, Dr. Nassau announced that a fine portrait painting of John Stockwell (the first professor of astronomy and also first president of Case at its founding in 1881), had been presented to the observatory and was available for inspection.

PAUL ANNEAR, *Recording Secretary.*

Our Presidents and Science

In order to celebrate the first hundred years of the American Association for the Advancement of Science, the Library of Congress has recently displayed an unusual exhibition on "Our Presidents and Science." It breaks new ground in historical research, and displays in a striking light the connection which has existed, throughout the entire 160 years of our national existence, between each

Chief Executive and the advancing science and technology of his day. Together with a handsome series of presidential portraits reproduced from paintings or photographs and presented to the Library by Pach Brothers of New York City, 112 pieces, carefully selected as the result of extensive investigation, are shown. No President is represented by fewer than two items, and for some there are as many as six, eight, or ten.

The connection illustrated may be either personal or official, and is frequently both. Certain Presidents, their active careers absorbed by law and politics, have had small opportunity for personal experience or study of the natural sciences, but all have been concerned with science and its practical consequences in invention and engineering, in the discharge of their official duties.

On the other hand, a number of our Presidents have been actively concerned with one or more of the sciences, and have made positive contributions to their progress.

George Washington made his start in life as a surveyor, and the Library is exhibiting a handsome manuscript map of his farm on Little Hunting Creek, drawn by him in 1766. He was an American pioneer of the new scientific agriculture, and within two years of his death, three separate collections of his agricultural correspondence had been published in Britain and America.

Foremost of the Presidents having individual scientific achievements was Thomas Jefferson, who was thoroughly grounded in the scientific knowledge of his era, and was active in observation, experiment, and invention throughout his life. Among the Jefferson pieces shown are a notebook of meteorological and other scientific observations—concerning such things as the variation of the compass and the depth of water in his well—kept up at Monticello for over 44 years; the first American contribution of palaeontology, Jefferson's paper on an extinct giant sloth read to the American Philosophical Society in 1797; a broadside amplifying his invention of a mould board, an improvement in the plough; the first public edition of his *Notes on Virginia* (London, 1787), the most detailed contribution to American geography that had then appeared; and official documents illustrating Jefferson's fundamental role in securing the scientific exploration of the Louisiana Purchase by the Lewis and Clark and other expeditions. During the eight years of his presidency, Jefferson was also president of our oldest scientific organization, the American Philosophical Society, a fact illustrated here by the official letter of notification of his reelection at the beginning of 1802.

John Quincy Adams, as Secretary of State in Monroe's cabinet, spent four years in the preparation of a 245-page Report on Weights and Measures (1821), one of the classics of this difficult subject. For nearly 20 years, he was a crusader for astronomical observatories in the United States, and was at length, in 1843, called to deliver the oration at the laying of the cornerstone of the earliest first-class one, in Cincinnati.

William Henry Harrison published the first contribution to the archaeology of the interior of the continent in 1838, when his *Discourse on the Aborigines of the Valley of the Ohio,* was printed as a pamphlet at Cincinnati. On display is a presentation copy from the author to Caleb Cushing, in the original wrappers.

Theodore Roosevelt was a practical naturalist, a keen observer of birds, an authority on the life-histories of game animals, and an explorer whose *Through the Brazilian Wilderness* (1914) was translated into Portuguese by the Brazilian Ministry of Agriculture as late as 1943.

Herbert Hoover is a distinguished mining engineer, author of a textbook on the *Principles of Mining* (*New York and London,* 1909). He was selected to

receive the highest American engineering award, the John Fritz Medal, just before his nomination to the Presidency.

All of our 27 other Presidents, while not scientists themselves, are illustrated in some striking scientific connection. John Adams, in writing the Massachusetts Constitution of 1780, enjoined legislators and magistrates to cherish the sciences and all seminaries of them. John Tyler, in a memorable letter of 1858 regretting his inability to appear at a banquet celebrating the beginning of the Atlantic cable, told in eloquent terms of his earlier relations with Samuel F. B. Morse and the beginnings of the telegraph. James A. Garfield founded his political career by defending the Fundamentalist side in a five-day debate on organic evolution. William McKinley, in an Annual Message, called for the concerted investigation of yellow fever which, within three years, tracked down the germ-bearing mosquito. Harry S. Truman, as Chairman of the Senate Committee Investigating National Defense, scrutinized every aspect of our stupendous technological achievement in World War II. The White House has furnished for the exhibition an original press release of Mr. Truman's recent address before the American Association for the Advancement of Science.

The whole exhibition indicated an intimate interrelation of scientific progress with the whole national existence of the United States. It was on view in the south gallery, second floor, of the Main Library Building until the end of November.

Book Reviews

Rockets and Space Travel, by Willy Ley. (The Viking Press, New York City. $3.75.)

In 1944 a book entitled "Rockets" was produced by the same author and publisher. The present volume, issued in 1947, is a rewriting and enlarging of the former one, as is somewhat indicated by the enlarged title. The author discusses his material under nearly the same list of chapter headings as before. However, the research which was expended upon rocket study between the two dates mentioned afforded the author many new facts. As a result, the book increased in size from 287 pages to 374 pages. The plan of development and a hint at some of the conclusions were set forth in a review, of the former book, published in POPULAR ASTRONOMY, **52**, 360 (1944), to which the attention of the interested reader is directed. C.H.G.

Theory of Equations, by J. V. Uspensky. (McGraw-Hill, New York, 1948. $4.50.)

The manuscript for this text was sent to the printer just before the death of the author, then professor at Stanford and formerly of the mathematics department at Carleton College. The book contains the usual material for a college course in theory of equations, but it differs from existing texts in two important respects. First, it is considerably more complete and explicit in its explanations, and second, a number of topics are treated in modern and, for a textbook, novel style. Complex numbers are treated as ordered pairs of real numbers, and determinants are introduced in an elegant manner due to Weierstrass. These departures from tradition make the subject no more difficult but considerably more illuminating. Minor weaknesses are the undue attention given to Horner's method, the implicit use of the principle of finite induction in several arguments, and the

choice of a rather complicated proof of the fundamental theorem of algebra in spite of the existence of shorter and intuitively equally satisfying demonstrations. All in all, the book is a welcome addition to the texts in the field and would be a good choice for independent study.

Carleton College. KENNETH MAY.

General Catalogue of Variable Stars, by B. V. Kukarkin and P. P. Parenago. (Published by the Academy of Sciences, U.S.S.R., 1948.)

One of the highlights of the Zürich meeting of the International Astronomical Union was the appearance of Dr. Kukarkin and the other Russian members of Commission 27 (Variable Stars) with their new edition of the Variable Star Catalogue. It is the first volume of the catalogue to appear since 1942 (Katalog und Ephemeriden Veränderlicher Sterne für 1942, Kleine Veröff. der Univ. zu Berlin-Babelsberg, Nr. 25). The original catalogue was compiled by Dr. Richard Prager (Kat. und Eph. Ver. St. für 1927, *ibid.*, No. 1) as agreed upon at the meeting of the Astronomische Gesselschaft Commission on Variable Stars in Copenhagen in 1926. He continued to publish the catalogue yearly through 1936, when it was taken over by Dr. H. Schneller, who carried on the work through 1942. At the interim meeting of the I.A.U. in Copenhagen in 1946, the Academy of Sciences of the U.S.S.R. and the Sternberg Astronomical Institute volunteered to carry on the work of publishing the catalogue.

The first number of the catalogue, by Dr. Prager, contained information on all the named variables of that time—a total of 2906 stars. Each new edition included all the variables which had been assigned names during the year, so the 1942 edition by Dr. Schneller contained 8830 stars, and this new edition (1948) by Dr. Kukarkin contains 10,912 stars.

The general appearance of the catalogue has changed considerably through the years. The current volume contains 528 pages, and is well bound in cloth covered boards. The coordinates of the variables are given for 1900, instead of the rather clumsy system of catalogue epochs of 1855 for northern stars and 1875 for southern ones. The most valuable addition to the main table, which is two pages wide, is the column which gives the authority and reference for the latest elements. There are also 10 pages of notes (in Russian) giving additional information about many of the variables.

In the back of the volume there are tables giving lists of variables of the following classes: Cepheid, cluster type, Algol, W UMa, eclipsing (unknown class), irregular, long period (not Mira), Mira, typical novae, nova-like, RT Ser, T Ori, R CrB, repeating novae, RV Tau, RW Aur, semi-regular, U Gem, XX Oph, Z Cam, β Cep, elliptical, unique, short period (unknown class), not investigated, not variable, erroneous names, non-existent, and super novae. There are also the table listing all variables in order of right ascension; tables giving names of stars which had been assigned Zinner and Prager numbers; a very useful table of Julian days for the first of each month from 1850 to 1950; and a table for changing hours and minutes to decimal of a day.

The main criticism of the volume is that the introduction and all remarks are written in Russian, which is a very difficult language for most astronomers outside of the U.S.S.R. At the meeting in Zürich, it was agreed that the I.A.U. would have the 20 or so pages translated into English and made available in some form. It is to be hoped that this will be done in the very near future.

According to Dr. Kukarkin's statement at the I.A.U. meeting in Zürich, a

large edition of the volume has been printed, and copies will be distributed free of charge to any astronomers who have need for them.

MARGARET WALTON MAYALL.
Harvard College Observatory, November, 1948.

Centennial Symposia, December, 1946. (Harvard College Observatory, Cambridge, Massachusetts, 1948. 385 pages. $5.00.)

Twenty-four authors contributed to these four symposia which are now collected in Harvard Observatory Monograph No. 7. The symposia were held as part of the celebration of the first hundred years of telescopic work at Harvard. They include the subjects: I. Interstellar Matter; II. Electronic and Computational Devices of Interest to Astronomers; III. Eclipsing Binaries; IV. The Gaseous Envelope of the Earth.

Three of the papers under I, by Bok, Spitzer, and Whipple, examine different aspects of the problem of star formation from interstellar clouds. Stebbins discusses interstellar reddening and absorption; Greenstein writes of faint stars imbedded in nebulosity and of the possible interactions of the stars and the nebular matter; and van de Hulst presents an interesting summary of recent Dutch work on the physics and evolution of interstellar particles.

The second symposium consists of three papers by Kron, Whitford, and Eckert. Kron considers optimum design of photoelectric devices for the measurement of very faint light; Whitford presents data relating to the application of the lead-sulfiide photoconductive cell to astronomical studies in the infrared; and Eckert discusses various electronic and electromagnetic devices for the measurement, computation, and recording of astronomical data.

In the third symposium, the first paper, by Henry Norris Russell, is entitled, "The Royal Road of Eclipses." It was given as the first of the annual Henry Norris Russell Lectures, and is an excellent summary of the whole field of eclipsing binaries by an author who has made many important contributions to the subject. Struve presents some important results obtained at the McDonald Observatory in recent years, bearing upon masses, mass ratios, and dimensions of eclipsing stars. Shapley gives evidence for the very frequent occurrence of intrinsically faint binaries of W Ursae Majoris type; Petrie discusses methods used and results obtained in a study of the relative luminosities of eclipsing stars; and Kopal points out important unsolved problems.

The final symposium is devoted to the relationship between solar activity and terrestrial phenomena including radio propagation and weather. This section of the book should be of interest not only to astronomers but to geophysicists and meteorologists as well.

Since the contributors to the symposia are all active workers in the fields of which they write, and since their papers are concerned with subjects more or less on the frontiers of current astronomical thought, the volume is a very stimulating one. It is to be recommended to every working astronomer, not only for its factual content, but, perhaps even more, for its suggestions of fields for further exploration.

O. C. WILSON.

Mount Wilson and Palomar Observatories.